New Scientist

WEEKLY 30 November 2024

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M&S FOOD

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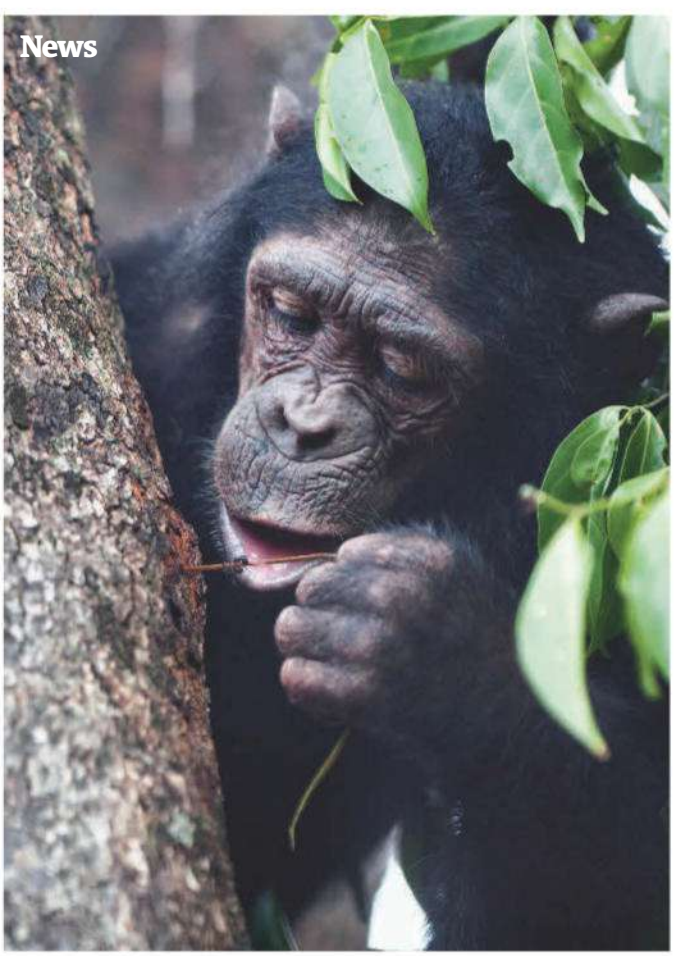

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Online event

Best of *New Scientist*

Join us for a review of the biggest scientific stories of the year, as told by the team at *New Scientist*. Plus, put your questions to our expert panel of journalists about their favourite articles of 2024 and what they predict will be the big science stories of 2025 and beyond. This subscriber-only online event starts at 6pm GMT/1pm EST on 10 December.

newscientist.com/events

Tour

Mysteries of the universe: Cheshire, UK

Over a weekend, based in a 4-star hotel, you will enjoy a series of fascinating lectures hosted by astronomy journalist Stuart Clark. Hear leading astrophysicists discuss the cosmos, from black holes to the James Webb Space Telescope. There is also an excursion to UNESCO World Heritage Site Jodrell Bank to see the iconic Lovell Telescope. This three-day Weekender starts on 27 June and costs £999.

newscientist.com/tours

Podcast

Weekly

In a food special, the team discuss why some people put weight back on after they have lost it and what the effects are of adding calorie labels to menus. There is a new study showing that AI chatbots can replicate people's unique thoughts and personalities. Plus, hear about how chimpanzee culture grows cumulatively across generations.

newscientist.com/nspod

NASA, ESA, CSA, STScI

Incredible nebula Discover cosmic secrets on a weekend trip

TIMOTHY HEARSUM/IMAGSTOCK/DESIGN PICS INC/ALAMY

Super cell A new kind of cheap battery can boost renewables

Video

Fearsome lava

A new volcanic eruption has occurred on Iceland's Reykjanes peninsula, the sixth this year, following the 15-kilometre-long crack that opened in January. Drone photographer Jeroen Van Nieuwenhove flew over the fissure caused by the volcano in the early hours of 21 November, filming the lava flow, which covers at least 7 square kilometres.

youtube.com/newscientist

Newsletter

Fix the Planet

Electric vehicle batteries are using up lithium reserves, but a cheaper alternative made from abundant sodium is being mass-produced in China, India, the US and Sweden. Sodium-ion batteries are less powerful and so largely won't be used in vehicles, but they can store energy produced by solar and wind farms.

newscientist.com/fix-the-planet

Podcast

"If chimp culture evolves, then why are they stuck scrabbling around in the dirt?"

Sale now on!

Our Black Friday & Cyber Monday Sale is here. Until 4 December, you can enjoy discounts at the New Scientist Shop. Whether you are a curious reader looking to expand your mind or whether you are searching for the perfect gift, now is the time to dive into everything the New Scientist Shop has to offer.

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‘Bel Can-do’

In November 2022 we introduced the Bel Canto. Instantly making haute horology accessible. This subtly chiming timepiece caused a cacophony. And enormous demand. (The first 600 sold out in 8 hours.) Asked could we produce 5,000 annually, our Swiss CEO Jorg Bader Snr replied: “No. But we’ll find a way.” Because that is our way. Today, our supply chain is as fit for purpose as the gear chain of the new Bel Canto Classic. Which features a dressed-up dial. A dialled-down handset. And a gorgeous guilloché finish, with a precision only achievable (and affordable) using a femto laser. Outward displays, we like to think, of inward grace.

(Bel Can-)Do your research

Christopher Ward

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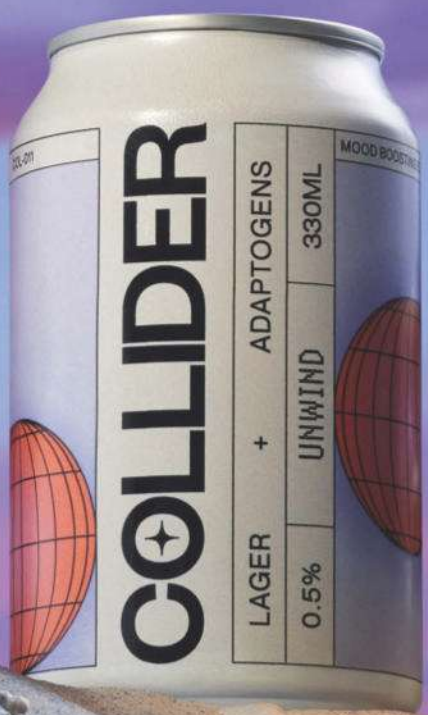

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Dealing with monsters

In both literature and science, banning ideas that sound scary holds us back

IN 1818, Mary Shelley invented a technology that has been used for both good and ill in the centuries since. It is called science fiction.

You may not think a literary genre counts as technology, but sci-fi stories have long been tools for predicting and critiquing science. Shelley's *Frankenstein*, regarded by many as the first true sci-fi novel, was powerful enough for South Africa to ban it in 1955. It set the formula with a tale that serves even today as a warning of unintended consequences.

The precise science employed by the eponymous Victor Frankenstein in his creation isn't, as far as we know, possible. But researchers today are able to bring dead human brains back to something resembling life. Experiments are under way to resume cellular activity (but, crucially, not consciousness) after death to test the effects of treatments for the likes of Alzheimer's disease (see page 32).

It is hard not to think of the many sci-fi tales dealing with similar scenarios and imagine what might happen next.

"The teams behind the work are blurring the lines of fact, fiction and what it means to be human"

The same is true of work reported on page 8, in which researchers are using the technology behind ChatGPT to replicate the thoughts and behaviours of specific individuals, with startling success.

In both cases, the teams behind this research, blurring the lines of fact, fiction and what it means to be human, are deeply aware of the ethical concerns involved in their work, which is being conducted with strong ethical oversight, and with its details made public at an early stage. But now that the technology has been demonstrated, there is nothing to stop more nefarious groups attempting the same, without oversight and with the potential to cause great harm.

Does that mean the research should be banned, as Shelley's book was, for fear of it getting into the wrong hands? Far from it. Concerns about tech are best dealt with through appropriate, evidence-based regulation and swift punishment for transgressors. When regulators overreach, we miss out not only on the technology but the chance to critique and discuss it. ▮

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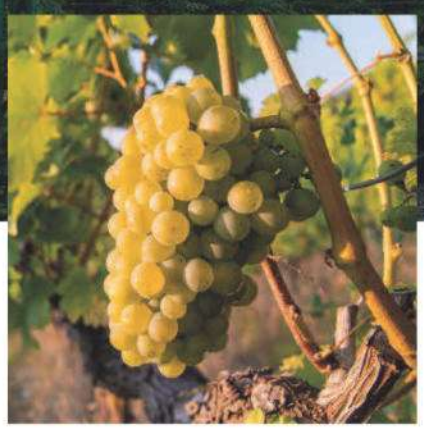
NewScientist

New tours to amazing places for curious minds



The science of champagne: Northeastern France

8 June 2025 | 5 days

Whet your appetite with an insightful champagne escape based in the heart of Reims in northeastern France. Explore the famous champagne houses of Taittinger, Bollinger and many more as you delve into both the history and production processes of champagne.

- Enjoy guided tastings with experts explaining the sensory characteristics of different champagne varieties.
- Learn about the grape-growing process, soil composition and climate that make the champagne region unique.
- Discover the underground cellars where bottles age for years, often in stunning chalk caves.
- Experience the rich history of the region, including its role in royal coronations and historical events.

The science of primary rainforests and wetlands: Malaysian Borneo

11 August 2025 | 10 days

Explore Malaysia's primary rainforests and wetlands, including the Kinabatangan wetlands, Tabin rainforest and the Danum Valley as Alfred Russel Wallace did before writing his 1869 book *The Malay Archipelago*.

- Expect to see many endangered species, including orangutans, sun bears, civet cats, langurs, gibbons, mouse-deers and a plethora of birds.
- Visit the Sepilok Orangutan Rehabilitation Centre, Bornean Bear Conservation Centre and the Rainforest Discovery Centre.
- Enjoy wildlife safaris, river cruises, treks and evening walks.
- Throughout the tour you will be accompanied by Martin Cohen, an experienced naturalist.
- Stay in rainforest lodges and nature resorts in the heart of the forest reserves.

Churchill polar bear expedition: Canada

21 October 2025 | 6 days

Travel to Churchill in northern Canada to see the world's greatest concentration of polar bears. Learn more about their evolutionary history and learn about the role ecotourism plays in the protection of polar bearsand Arctic biodiversity.

- Experience intimate polar bear encounters, spending five days exploring the Churchill area among the world's greatest concentration of polar bears.
- Enjoy an exclusive tundra excursion after dark that provides a unique perspective, including the chance, on a clear night, to view the northern lights away from town.
- Travel aboard the newest fleet of technologically advanced Polar Rovers, with huge windows and a see-through outdoor viewing deck, to get you closer to the bears.

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News

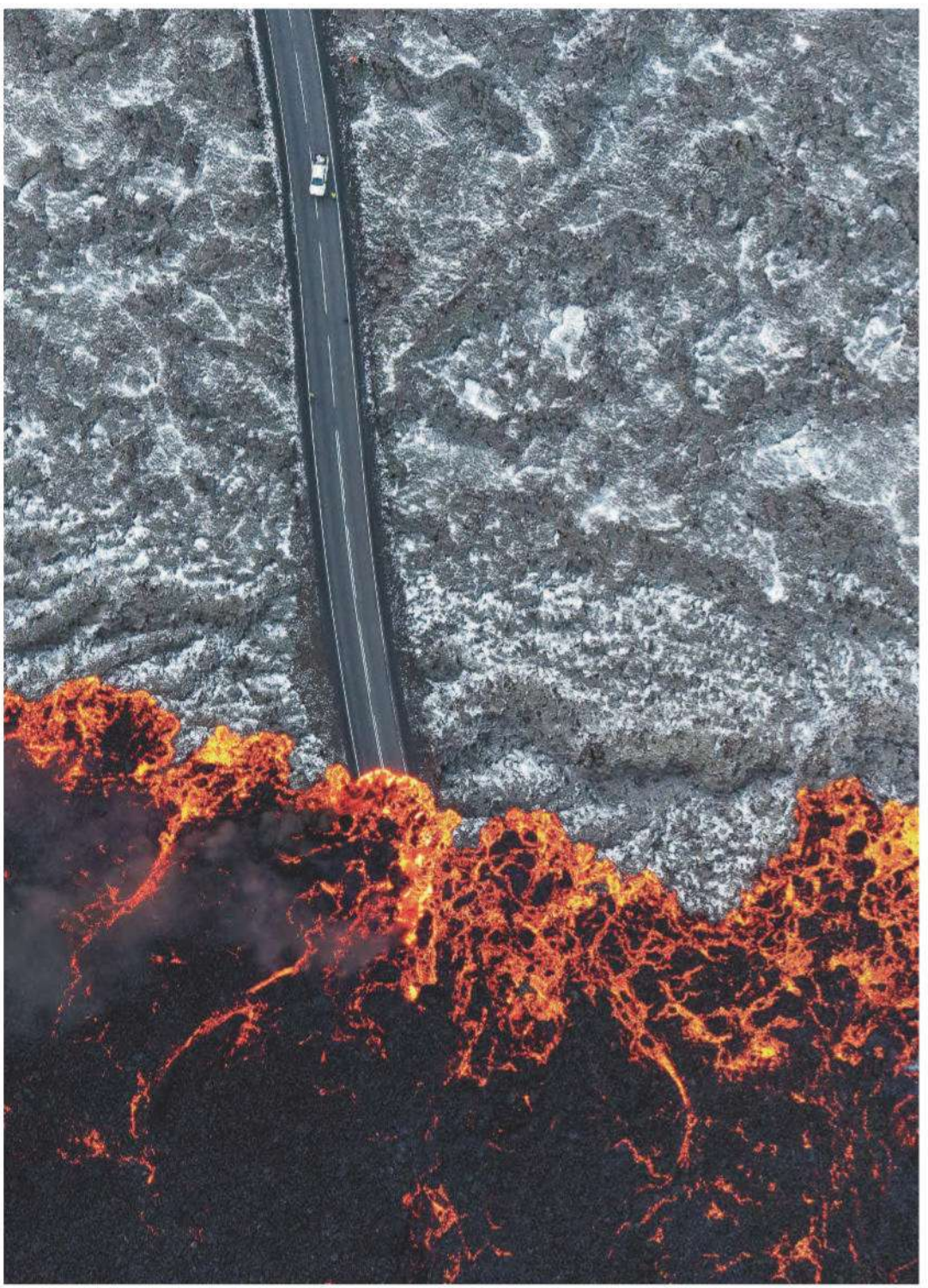
Lab-grown wood
Wood created from stem cells to reduce tree felling p10

Nectar hunters
Wolf species may be first known carnivore pollinator p10

It's not aliens
Bacteria in asteroid sample probably from Earth p15

Always right
Einstein's theories tested on the largest scale ever p17

Invasion threat
Enormous hornet appears in Europe for first time p18



ANTON BRINK/EPA-EFE/SHUTTERSTOCK

Earth science

Lava heads to Icelandic spa

This molten lava hit the road on the Reykjanes peninsula, Iceland, last week – heading towards the Blue Lagoon geothermal spa, a major tourist destination. The lava erupted from a fissure about 3 kilometres long that opened up near the Sundhnúksgígar craters on 21 November. It is the sixth eruption there this year, but the lava's impact is localised and, despite its direction of travel, poses no threat to people.

Technology

AI can mimic individual people

The personalities of specific people have been replicated with AI agents as part of an effort to create an alternative to polling that also raises ethical concerns. **Chris Stokel-Walker** reports

AN EXPERIMENT simulating more than 1000 real people using the artificial intelligence model behind ChatGPT has successfully replicated their unique thoughts and personalities with high accuracy, sparking concerns about the ethics of mimicking individuals in this way.

Joon Sung Park at Stanford University in California and his colleagues wanted to use generative AI to model individuals as a way of forecasting the impact of policy changes. Historically, this has been attempted using more simplistic rule-based statistical models, with limited success.

"We really had to simplify human behaviour a lot to make these models," says Park. "What we have the opportunity to do now is create models of individuals that are actually truly high-fidelity. We can build an agent of a person that captures a lot of their complexities and idiosyncratic nature."

To build the AI-generated agents, the team recruited 1052 people in the US, representative of the wider population. Each participant took part in a 2-hour speaking interview with a voice-enabled version of GPT-4o, the most sophisticated version of the model that powers OpenAI's ChatGPT tool. The AI was given a general script to follow but also instructed to listen to the answers in real time and adapt its questions as needed, asking participants for the story of their life and views on societal issues. The researchers then fed an AI-generated transcript of each interview into a different instance of GPT-4o and asked the model to imitate each person.

The team put each of these AI agents through a range of tests, including a long-running social attitudes survey called the General Social Survey (GSS), an assessment

SHUTTERSTOCK/BLVDONE

Varied as humans are, AI seems able to replicate our responses

of the "big five" personality traits, five behavioural economic games and five social science experiments. The original human participants were also given the same tests twice, two weeks apart.

In general, the AI agents closely followed the participants' responses to tests. The humans didn't give identical answers two weeks later, with a match of about 81 per cent between the two testing sessions for the GSS. In turn, the AI agents had a raw accuracy of around 69 per cent against the first GSS testing session, meaning they were essentially 85 per cent accurate when considering the differing human answers between the two sessions. The accuracy figures were similar, if slightly lower, for the other tests. The AI agents also outperformed simpler, demographic-based models at matching the responses of individuals by 14 percentage points (arXiv, doi.org/ntfk).

"We didn't quite know what we were expecting," says Park, though he suspected that it would be possible for AI models to do well on these tests given anecdotes of ChatGPT users finding the AI could intuit facts about them. "It was a nice scientific validation."

Park says his "core motivation" is to provide better tools for policy-makers to test out the impact of their proposals in a more nuanced way than broad-brush modelling of populations. While some may worry that the ability to replicate human emotions would be a gold mine for marketers, the ethical approval the researchers sought from participants limits the use of the agents and their underlying data "strictly for academic purposes", he says.

"The potential of effective simulated human behaviour to trial the impact of policy is vast"

"The potential of effective simulated human behaviour to trial the impact of policy is vast," says Richard Whittle at the University of Salford, UK. Politicians could also use these tools to test messaging, he says, in a faster and cheaper way than focus groups or polling.

Yet Whittle sounds a note of caution. "Human behaviour is delightfully complex and context dependent," he says. "Simulated groups may be very useful, but if the context changes significantly, human response will likely still be the go-to."

Potential for problems

Being too quick to rely on AI agents could create issues, says Catherine Flick at the University of Staffordshire, UK. "While I think this is really interesting research, I think that it has some quite problematic potential," she says. "The [agents are] never going to understand [anything], because they can't understand what it is to be in a community."

The work also raises broader questions about the ethics of mimicking individual humans' behaviour so accurately. While there is no suggestion that the AI agents are alive or conscious in a *Black Mirror*-style simulation, even Park and the team were keen to engage with such concerns.

"We take the ethics extremely seriously," says Park. He points out that any participants who want to can withdraw their data – and therefore their AI agent – from the study or from being accessed by other researchers. "This is a huge opportunity, but we are also extremely cautious about not making this feel to set a bad precedent that's going to impact our society in ways that are creepy or not empowering to individuals." ▮

Anger over COP29 finance deal threatens progress on carbon cuts

A reluctant deal finalised at the climate summit may not be generous enough to encourage nations to submit more ambitious climate plans, says **Madeleine Cuff**

AFTER a long and fraught night of talks, COP29 in Baku finally concluded in the early hours of 24 November with a deal that will see wealthier countries funnel billions of dollars to poorer countries over the next decade to pay for climate action. Despite the high numbers involved, it is a deal that seemingly pleases no one, and has called the COP climate summit process into question.

The finance deal was the main focus of the meeting in Azerbaijan's capital, with lower-income countries lobbying for $500 billion a year of support from higher-income countries. Negotiations were tense, as nations contending with inflation, strained domestic budgets and political instability balked at such a large spending

"This deal, in our opinion, will not address the enormity of the challenge we all face"

commitment. At one point during the final stretch, talks looked on the brink of collapse as poorer nations walked out of discussions.

Eventually, nations agreed on a package that would see wealthier countries pay at least $300 billion a year in grants and low-interest loans to poorer nations by 2035, as part of a wider target to mobilise $1.3 trillion in climate finance a year. The source of the extra $1 trillion hasn't been agreed, but could include private investment.

Speaking at the summit, COP President Mukhtar Babayev said the package was the "best possible deal we could reach". Avinash Persaud at the Inter-American Development Bank said the deal was "at the boundary between what is politically achievable today in developed countries and what would make a difference in developing countries".

But the agreement was widely condemned by poorer nations and campaigners as inadequate to meet the scale of need facing these countries, which are grappling with both building zero-emission economies and coping with increasingly extreme weather.

Moments after the deal was gavelled through by Babayev, India's representative Chandni Raina criticised the package, which she said her country didn't support. "We are disappointed in the outcome which clearly brings out the unwillingness of the developed country parties to fulfil their responsibilities," she said. "This, in our opinion, will not address the enormity of the challenge we all face."

India, which will receive funding under the deal, is one of dozens of high-emitting nations that needs to submit a fresh climate plan to the UN by 2025, ahead of next year's talks in Brazil. Its emissions are set to grow by 4.6 per cent this year, and its current plan to cut emissions is rated as "highly insufficient" by Climate Action Tracker, an independent body that assesses governments' climate plans.

SEAN GALLUP/GETTY IMAGES

India's delegate Chandni Raina criticised the climate aid deal struck at COP29

Limiting warming to between 1.5°C and 2°C, as set out in the Paris Agreement, depends on countries like India submitting much bolder carbon-cutting plans – known as nationally determined contributions (NDCs) – to the UN in February. Campaigners had hoped a successful agreement to provide more cash for poorer countries would unlock more ambition from these nations.

The disagreements over finance in Baku have left delegates heading home with a bitter taste in their mouth, and poorer countries are already warning that the deal does little to build enthusiasm for further ambition. "We are extremely disappointed in the outcome, which undermines any goal of having ambitious NDCs and signals a lack of goodwill by developed countries," Sierra Leone's environment minister, Jiwoh Abdulai, said in a statement.

The often chaotic scenes in Baku, run by a presidency with little experience in climate negotiations and extensive fossil fuel interests, has also raised wider questions about the future of UN climate summits. During the meeting, an open letter signed by COP veterans, including former UN secretary-general Ban Ki-moon, was released calling for the climate meetings to become more "streamlined", with a greater focus on delivering carbon-cutting policies. The letter also called for hosting rules to be tightened, to only allow those countries taking ambitious climate action to hold the presidency.

It will be up to the Brazilian government to repair faith in the COP process as a vehicle for driving action when it hosts COP30 in Belém next year. Brazilian President Luiz Inácio Lula da Silva has described that meeting as a "turnaround COP", with a focus on accelerating the transition to net-zero emissions and fleshing out the details of the finance commitment made in Baku.

"This COP process needs to recover from Baku," said Li Shuo of the Asia Society Policy Institute, a US think tank, in a statement. "It requires more leadership to deliver an outcome in line with 1.5°C next year in Brazil." ▮

AP PHOTO/PETER DEJONG/ALAMY

Demonstrators outside the climate conference have been calling for stronger action

Materials science

Sliver of wood grown from stem cells

Culturing wood in the lab could be an alternative to felling rare trees for lumber

James Dinneen

A TINY fragment of lab-grown wood could be a big step towards reducing the number of trees felled to meet lumber demands.

"As far as we know, our early prototype is the first piece of interconnected wood-like tissue ever produced from cell culture," says Tom Clement at start-up New Dawn Bio.

What the firm calls "cultured wood" is the arboreal equivalent of lab-grown meat. The first piece of material was made using stem cells from *Arabidopsis thaliana*, a small, mustard-like plant commonly used in lab studies. The splinter, which Clement says is dark brown, is only about an eighth of the size of a postage stamp. The goal, however, is to use stem cells from various tree species and to produce larger pieces of wood, such as an entire tabletop or a chair.

The company aims to produce wood more efficiently and with a lower environmental impact than cutting down and processing

NEW DAWN BIO

Start-up firm New Dawn Bio is growing plant stem cells in culture

actual trees. Clement says the approach involves two main stages. First, plant stem cells are put in sugar water, enabling them to grow fast. Then, they are exposed to chemical or genetic cues to make them differentiate into fibre cells filled with cellulose – the primary component of plant cell walls – or vessel cells, which help transport water and minerals through the tissue. Together, these are the main structural components of wood.

Finally, when these cells "become strong and adhere to each other", they are combined to form any shape, says Clement. The team is working on finding the best growing conditions for stem cells from different tropical hardwood species, such as teak.

Eventually, the researchers aim to use these cells to replicate wood from tropical hardwood trees that are threatened by illegal logging. Clement says focusing on these rare species means cultured wood could displace harmful logging with relatively small-scale production. Lab-grown wood would be expensive, but it could still compete with costly wood from rare trees.

This isn't the first time scientists have tried to create cultured wood. Researchers previously reported using plant stem cells to print wood-like material. However, that team was never able to produce material with the same mechanical properties as actual wood, says Luis Fernando Velásquez-García at the Massachusetts Institute of Technology. "The million-dollar question is whether [the cells] connect. Are they just lumped together, or are they shaking hands?"

"The million-dollar question is if the cells connect. Are they lumped together or are they shaking hands?"

Clement declined to share details about how the cells connect or the mechanical properties of the resulting wood.

Velásquez-García says it would be "big" if New Dawn Bio has solved this problem, but without more details on the splinter's mechanical properties, it is impossible to judge whether the start-up has done so. ▮

Zoology

Ethiopian wolves may be first known carnivore pollinators

BY FEEDING on the sweet nectar of a local flower, picking up pollen on their snouts as they do so, a wolf species may be the first carnivore known to act as a pollinator.

The Ethiopian wolf (*Canis simensis*) is the rarest wild canid species in the world and Africa's most threatened carnivore. Endemic to the Ethiopian Highlands, fewer than 500 individuals survive.

Sandra Lai at the University of Oxford and her colleagues observed wild Ethiopian wolves lapping up the nectar of Ethiopian red hot poker (*Kniphofia foliosa*) flowers. Local people have traditionally used the nectar as a sweetener for coffee and on flat bread.

The wolves are thought to be the first large carnivore species ever to be recorded regularly feeding on nectar.

"For large carnivores, such as wolves, nectar-feeding is very unusual, due to the lack of physical adaptations, such as a long tongue or specialised snout, and because most flowers are too fragile or produce too little nectar to be interesting for large animals," says Lai.

The sturdy, nectar-rich flower heads of the poker plant make this behaviour possible, she says.

ADRIEN LESAFFRE

An Ethiopian wolf licking nectar from an Ethiopian red hot poker flower

"To my knowledge, no other large carnivorous predator exhibits nectar-feeding, though some omnivorous bears may opportunistically forage for nectar."

Some of the wolves were seen visiting as many as 30 blooms in a single trip. As they lick the nectar, the wolves' muzzles get covered in pollen, which they could potentially be transferring from flower to flower as they feed (*Ecology*, doi.org/ns9x).

"The behaviour is interesting because it shows nectar-feeding and pollination by non-flying mammals might be more widespread than currently recognised," says Lai. ▮

Graeme Green

Solar system

Meteorite crystal hints at hot water on ancient Mars

James Woodford

A CRYSTAL inside a Martian meteorite suggests there was plentiful hot water on Mars when the rock formed about 4.45 billion years ago.

The rock, nicknamed Black Beauty, was blasted into space by an impact on the surface of Mars before ultimately crashing into the Sahara desert. Much has already been learned from studying the meteorite, which was discovered in Morocco in 2011 and is formally known as Northwest Africa 7034.

Aaron Cavosie at Curtin University in Perth, Australia, and his colleagues have been studying a fragment of it that includes a zircon crystal just 50 micrometres across.

The piece was crystallised in magma below the Martian surface. Cavosie and his colleagues discovered that the zircon crystal also contained iron, aluminium and sodium, neatly arranged in thin layers like that of an onion (*Science Advances*, doi.org/g8rqdj).

Elements like this are also found in zircon crystals at a gold ore deposit site in South Australia, says Cavosie.

"These kinds of zircons are only known to form where hydrothermal processes, hot water systems, are active during magmatism," he says. "The hot water facilitates transportation of the iron, aluminium and sodium into the crystal as it grows, layer by layer."

The absence of radiation damage to the Martian zircon means the extra elements were part of the crystal to begin with, rather than contaminating it later, says Cavosie.

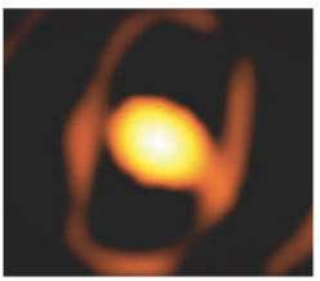
Eva Scheller at Stanford University in California says if the rock did form in the presence of hot water and magma under the surface of Mars, that suggests the possibility of water vapour being released into the planet's atmosphere before the formation of rivers and lakes. ▮

Astronomy

Photo taken of a star in another galaxy for first time

Alex Wilkins

ESO/Y. BELETSKY



ESO/K. OHNAKA ET AL.

The Very Large Telescope Interferometer (left) has taken the above picture of giant star WOH G64, which sits in the Large Magellanic Cloud (boxed, left)

ASTRONOMERS have captured the first detailed picture of a star in another galaxy, more than 160,000 light years away. The giant star may be showing signs that it is just years away from exploding, a process we have never seen in detail.

The largest stars ever glimpsed are red supergiants, which are stars that have run out of hydrogen fuel in their cores. A shell of hydrogen gas surrounding the core burns instead, massively expanding the volume of the star.

One of the largest red supergiants we know of is WOH G64, sometimes called the behemoth star. It is between 1540 and 2575 times the size of the sun and resides in a satellite galaxy of the Milky Way, the Large Magellanic Cloud. The star has been a target for astronomers since it was discovered in the 1970s, but its distance has made it hard to examine closely.

Now, Jacco van Loon at Keele University in the UK and his colleagues have taken a close-up picture of WOH G64 using the Very Large Telescope Interferometer in the Atacama desert in Chile, a collection of four individual telescopes linked together to function as if they were a single, 200-metre telescope. "In this image, we can see detail which would be equivalent to seeing an astronaut walking on the moon," says van Loon. "You can't see that through a normal telescope pointing at the moon."

The image, which was taken using infrared light, shows a bright ball of gas and dust, at more than 1000°C, that the star has pumped out and that now surrounds it as a dense cocoon (*Astronomy & Astrophysics*, doi.org/g8rmd7).

2575

Giant star WOH G64 may be this many times the size of the sun

"It's really a structure we had not expected to actually see," says van Loon. "We had expected just to see the star in the middle."

The star appears dimmer than when it was last observed, so the gas and dust probably appeared relatively recently, says van Loon. It might have been produced by the star blowing off its outer layers, which astronomers have never captured in a red supergiant.

If that is what happened and the process resembles one seen in similar stars called blue supergiants, then it might be a sign that the star is decades or years away from exploding.

"If we can see this star explode, we have much more detail about a star before it's exploded than ever before," says van Loon.

"It's technically extremely impressive to be able to reconstruct an image of this object given its extreme distance," says Paul Crowther at the University of Sheffield, UK.

However, it is harder to say for certain whether the observed gas and dust, and the associated dimming in brightness, are a sign of an imminent explosion.

"Stars like this object are well known to be highly variable," says Crowther. "It's simply what happens in these objects where they have this dense, slow outflow that doesn't go very far from the star. They're well known to be dust factories." ▮

Technology

The coming quantum revolution

Computers that exploit quantum physics to speed up calculations are making great strides, find **Karmela Padavic-Callaghan**, **Matthew Sparkes** and **Alex Wilkins**

QUANTUM computers promise to solve certain problems much faster than conventional devices, but major hurdles remain, such as making the computers large enough while reducing errors. Last week, three big players in the burgeoning quantum industry demonstrated new techniques that together suggest the day these machines actually become useful is drawing closer.

First, IBM has made a significant advance on the road to larger and more powerful quantum computers by linking two devices together so they can perform calculations beyond the capabilities of either alone.

IBM is using superconducting chips that can be produced by the same machines that make existing computer hardware. One issue with this choice is that the input and output wires for the chips are far larger than the quantum bits, or qubits, that do the calculating. This means the qubits must be spaced further apart than the transistors in a conventional processor, reducing the number that can be squeezed onto a chip. That is why IBM wants to be able to link up its chips.

"It's a game that you win by sort of breaking it up into chunks," says Blake Johnson at IBM. "This is a central choice, [an] engineering choice we've made in terms of how we're scaling up our systems. And there are scientific questions to answer as well as engineering questions to answer about the consequences of that choice."

That is because getting quantum chips to communicate with each other is much more difficult than doing so with conventional chips, where data is represented by the absence or presence of an electrical signal. Quantum computers instead rely on the strange physics of quantum entanglement, which can't simply be transmitted by a wire.

To get around this, researchers have developed a method to entangle a pair of qubits and teleport one to a second chip, forging a quantum link between the two devices that must be mediated by a conventional computer. IBM has now successfully demonstrated this by connecting two of its Eagle quantum processing units, each with 127 qubits, to perform a calculation requiring a total of 142 qubits – more than could fit at one time on either chip (*Nature*, doi.org/ntdd).

Early steps

Scott Aaronson at the University of Texas at Austin says IBM has now demonstrated an early step towards a goal discussed for decades. "Really scaling up superconducting quantum computers will require a much more high-fidelity version of the same thing, one that would let hundreds or thousands of superconducting chips operate as one."

On the error correcting front, the technology is progressing in multiple directions. One promising approach is to connect physical qubits into groups called logical qubits, where some are used for computation while others are reserved as error-detection tools. Microsoft and Atom Computing say they have set a new record for the most entangled logical qubits, a crucial step towards useful computation (arXiv, doi.org/ntdf).

The firms used a quantum computer constructed from ultracold ytterbium atoms to create 24 logical qubits and linked them through entanglement. "We are co-designing and building the world's most powerful quantum machine," says Krysta Svore at Microsoft. "To my knowledge, this is the largest entangled state of logical qubits."

She says this opens the door to using logical qubits to run algorithms, including those for error correction. In fact, to create this entangled state, the team has already successfully employed some error-correction techniques, she says. In preliminary tests, using these logical qubits for simple calculations had an error rate about four times lower than when using conventional qubits.

Manuel Endres at the California Institute of Technology says the work "indicates that error correction with thousands, if not tens of thousands, of physical qubits is a near-term prospect".

A display model of IBM's Quantum System Two computer

ARIJAN MURAT/DPA/ALAMY

6%

Reduction in quantum computing errors when using AlphaQubit AI

Svore and her colleagues are already working towards creating 50 logical qubits and eventually want to make 100 of them, which they estimate would be sufficient to achieve real breakthroughs in using quantum computers for materials science or chemistry.

Lastly, Google DeepMind has taken a different approach to error correction, using artificial intelligence to interpret information from error-detecting qubits. This difficult task, known as decoding, is usually performed by a classical algorithm and success is closely tied to the overall error correction capacity of a quantum computer, which, in turn, dictates its ability to run useful real-world tasks.

Johannes Bausch at Google DeepMind and his colleagues have now developed an AI model called AlphaQubit that can decode these errors more efficiently and more quickly than any existing algorithm.

"Designing a decoder for quantum error correction code is, if you're interested in very, very high accuracy, highly non-trivial," Bausch told journalists at a

press briefing on 2 November. "AlphaQubit learns this high-accuracy decoding task without a human to actively design the algorithm for it."

AI-powered

Bausch and his team used a transformer neural network – the same technology that powers the Nobel prize-winning protein-prediction AI, AlphaFold, and large language models like ChatGPT – to learn how data from error-detecting qubits corresponds to qubit errors. They first trained the model with data from a simulation of what the errors would look like, before fine tuning it on real-world data from Google's Sycamore quantum computing chip.

In experiments on a small number of qubits on the Sycamore chip, Bausch and his team found that AlphaQubit makes 6 per cent fewer errors than the next-best algorithm, called a tensor network. This improvement may seem small, but tensor networks become increasingly slow as quantum computers get bigger, so can't scale to future machines, whereas AlphaQubit appears to be able to run just as quickly, according to simulations. That makes it a promising tool as these computers grow, says Bausch (*Nature*, doi.org/g8rmrx).

"It's tremendously exciting," says Aaronson. "It's been clear for a while that decoding and correcting the errors quickly enough, in a fault-tolerant quantum computation, was going to push classical computing to the limit also. It's also become clear that for just about anything classical computers do involving optimisation or uncertainty, you can now throw machine learning at it and they might do it better." ▮

Zoology

Chimpanzees seem to pass on technological advances to others

Christa Lesté-Lasserre

MANOJ SHAH/GETTY IMAGES

Some chimpanzees use sticks to fish out termites to eat

WILD chimpanzees seem to learn skills from each other and then – much as humans do – improve on those techniques from one generation to the next.

In particular, young females that migrate between groups bring their cultural knowledge with them, and groups can combine new techniques with existing ones to get better at foraging for food. Such "cumulative culture" means some chimpanzee communities are becoming more technologically advanced over time – albeit very slowly, says Andrew Whiten at the University of St Andrews, UK.

"If chimpanzees have some cultural knowledge that the community they're moving into doesn't have, they may pass it on – just in the same way they're passing the genes on," he says. "And then that culture builds up."

Scientists already knew that chimps are capable of using tools in sophisticated ways and passing on that knowledge to offspring. But in comparison with the rapid technological development of humans, it seemed chimpanzees weren't improving on past innovations. The fact that chimp tools are often made from biodegrading plants also makes it difficult for scientists to track their cultural evolution, says Whiten.

To see if young females – which leave their communities to find mates elsewhere while males stay put – bring their skill sets into their new groups, Whiten and his colleagues looked at data on 240 chimpanzees representing all four subspecies. The data was previously collected by other research groups at 35 study sites in Africa and included information about what tools, if any, each animal used, as well as their genetic connections over the past 15,000 years.

> **"The genetics give us a kind of time machine into the way culture has been transmitted"**

"The genetics give us a kind of time machine into the way culture has been transmitted across chimpanzees in the past," says Whiten.

Some chimpanzees used complex combinations of tools, for example a drilling stick and a fishing brush fashioned by pulling a plant stem between their teeth, for hunting termites. The researchers found the chimpanzees with the most advanced tool sets were three to five times more likely to share the same DNA than those that used simple tools or no tools at all, even though they might live thousands of kilometres away. Advanced tool use was also more strongly associated with female migration than simple or no tool use (*Science*, doi.org/g8rmtx).

"Our interpretation is that these complex tool sets are really invented by perhaps building on a simpler form from before, and therefore they have to depend on transmission by females from the communities that invented them initially to all the other communities," says Whiten.

"It shows that complex tools would rely on social exchanges across groups," says team member Cassandra Gunasekaram at the University of Zurich in Switzerland.

Thibaud Gruber at the University of Geneva says the definition of complex behaviour is debatable. His own team, for example, has found what they called cumulative culture in chimpanzees that make sponges out of moss instead of leaves. This is no more complex, but works more efficiently to soak up mineral-rich water from clay pits. "It's not a question of being more complex, but of just having a technique that builds on a previously established one," he says. ▮

Analysis Public health

Are calories on menus doing more harm than good?

Many restaurants in the UK and US now print a dish's calorie count on their menu, but is this really tackling obesity, asks **David Robson**

WHEN you go to a restaurant, you may well be presented with a wide array of dishes, each printed on a menu alongside its calorie content. A chicken burger and fries may come to 1597 kilocalories. Swap the meat for a plant-based substitute, and it could rise to 1746 kcal. Opting for the vegan bacon ketchup adds another 300 kcal.

Since 2022, these calorie labels have been compulsory for any restaurant, café or takeaway chain in England with more than 250 staff, as part of an anti-obesity campaign launched in 2020 by the government of the then UK prime minister Boris Johnson. Yet the benefits to public health are contentious, with emerging studies raising serious questions about the assumed effects on consumer behaviour.

"The idea is that having more information means that people will make better decisions," says Mike Essman at the University of Cambridge. "But there may be so many other, potentially stronger, effects that are going to affect their decisions. People may think about, say, value for money rather than lower calories."

England's policy follows the US's example. New York City took the lead in 2008 and, a decade later, calorie labelling became mandatory across the US for any restaurant chain with more than 20 locations. A study from 2018 suggested that people chose slightly lower-calorie meals as a result, with an average reduction of 47 kcal – which makes up around 2 per cent of the daily recommended calorie intake for a man and 2.5 per cent for a woman.

Using this figure, Zoé Colombet at the University of Liverpool in the UK and her colleagues recently constructed a mathematical model to predict the long-term consequences of the policy for the body mass index and cardiovascular disease risk of people in England over 20 years. The results predicted a decrease of just 0.31 percentage points in the prevalence of obesity, and 730 fewer cardiovascular deaths by 2041.

JEFFREY ISAAC GREENBERG 16+/ALAMY

Calorie labelling is mandatory in the US for chains with more than 20 restaurants

This may seem like a small effect, especially given that 830,000 cardiovascular deaths are expected over that period, but Colombet says it shouldn't be totally discounted. "Reducing obesity and preventing deaths cannot be disappointing for me, especially for a policy that does not seem to increase health inequalities nor affect people's purchasing power," she says. The model also suggests that the policy could prevent up to 9200 deaths if it were expanded to include every eatery, not just large chains.

47 kcal
average reduction in calorie intake per meal with labelled menus, according to a 2018 study

730
fewer UK cardiovascular disease deaths predicted by 2041 based on that calorie intake reduction

35%
of calorie counts on surveyed UK menus weren't accurate

But the UK government may wish to consider other strands of evidence before expanding the strategy in England. Megan Polden, also at the University of Liverpool, worked with Essman and their colleagues to survey 3000 diners before the legislation was introduced and another 3000 afterwards. They found that having calories on menus made no significant change to people's eating choices.

There may be a moral argument for making people aware of what they are purchasing and eating, says Essman. "But people may need more support in order to use the information." For example, menus could include infographics that illustrate what a balanced meal looks like, he says.

Information is also only useful if it is accurate. The guidelines require the calorie counts to lie within a 20 per cent margin of error, but a study by Amy Finlay, also at the University of Liverpool, along with Polden and their colleagues showed that 35 per cent of calories printed on sampled menus sit outside this range.

The errors included both under and overestimations, which may have come about due to variations in portion sizes or the methods used to calculate the content. There is no reason to believe that outlets are deliberately misleading consumers, but this uncertainty may reduce the public's trust in the policy, says Finlay.

The approach's potential to reduce obesity should also be balanced against how it may influence people with eating disorders. A 2017 study found that listing calories on menus may make people with anorexia or bulimia order food with fewer calories, whereas people with binge eating disorder may be more likely to order meals with more calories.

"People are talking about how they now feel like they can't go into certain restaurants because they fear that it will set back their recovery," says Tom Quinn at the UK eating disorders charity Beat.

Whether the new UK government will refine the policy in England remains to be seen, but such research may influence other nations. The Scottish government, for instance, has paused plans to introduce mandatory calorie labels while it appraises the long-term consequences.

When the stakes for physical and mental health are so high, the public deserves a decision based on the strongest science rather than assumptions. "You could say that the policy is a step in the right direction, but we need a better understanding of the ways that people are interacting with that information," says Essman. ▮

Space

Bacteria found in asteroid sample brought back to Earth – but they aren't from space

Alex Wilkins

A ROCK that was brought back from the asteroid Ryugu appears to host microbial life. But these microbes almost certainly came from our planet rather than outer space, say researchers. This contamination serves as a cautionary tale in the search for extraterrestrial life in sample return missions, such as from NASA's Perseverance rover on Mars.

In 2020, Japan's Hayabusa 2 spacecraft returned to Earth with 5.4 grams of rock from the 4.5-billion-year-old asteroid Ryugu. After the sample capsule landed in Australia, it was taken to a facility in Sagamihara, Japan. There, the capsule was opened in a vacuum room, itself located in a clean room, before being moved to a pressurised nitrogen-filled room for longer-term storage. From there, parts of the sample could be put inside nitrogen-filled containers and sent out for study.

One sample was sent to the UK to be studied by Matthew Genge at Imperial College London and his colleagues. Genge's team initially scanned the sample using X-rays and saw no evidence of bacteria.

Three weeks later, the researchers transferred the sample to a resin, and after another week they examined it using a scanning electron microscope (SEM). When they saw what looked like filament-shaped bacteria, Genge's students were almost "falling off their chairs" at the prospect they had discovered extraterrestrial life. "It was an exciting moment, but also in the back of my mind I knew from previous studies how easy it is for bacteria to colonise rocks," he says.

"Students were almost falling off their chairs at the prospect of discovering extraterrestrial life"

By tracking the growth of the bacteria with follow-up SEM measurements, they found the number of bacteria changed in a similar way to known microorganisms (*Meteoritics & Planetary Science*, doi.org/ntfh). Combined with their familiar shape and their absence during the first X-ray scan, it is likely they were terrestrial in origin, says Genge.

He suspects the sample was contaminated when or after it was embedded in resin. This took place in a facility that was also handling terrestrial space rocks, which often contain bacteria that are adapted to living in rock specimens. "When we're preparing meteorite samples, for example, we usually don't see this colonisation occurring, and that's because the chances are really low," says Genge. "In this case, a single bacterium fell on that sample and started to grow," he says. "It only needs one bacterium or one bacterial spore in order for this to happen."

The work should serve as a warning for future sample return missions, adds Genge. "The discovery of microbes within a space return sample really should be the gold standard for discovering extraterrestrial life," he says. "But our discovery really shows that you have to be so incredibly careful about that interpretation, because samples are so easy to contaminate with terrestrial bacteria."

Javier Martin-Torres at the University of Aberdeen, UK, says the findings suggest a terrestrial origin, but this doesn't rule out that the bacteria came from elsewhere. "When you want to determine that those microorganisms are not from an extraterrestrial origin, then you should do some DNA sequencing," he says.

The work also boosts the idea of bacteria surviving elsewhere in the universe. "Microorganisms can utilise organic materials within meteorites in order to sustain themselves – they are dining out on extraterrestrial snacks," says Genge. ▮

Technology

Robotic pigeon reveals how birds fly without a vertical fin

A PIGEON-inspired robot has solved the mystery of how birds fly without the vertical tail fins that aircraft rely on. The prototype could lead to passenger aircraft with less drag, reducing fuel consumption.

Tail fins, also known as vertical stabilisers, allow aircraft to turn from side to side and help prevent unintentional changes in direction. Some military planes, such as the Northrop B-2 Spirit, are designed without a tail fin because it makes them less visible to radar. Instead, they use flaps that create extra drag on just one side when needed, but this is an inefficient solution.

To investigate how birds stay in control without a vertical fin, David Lentink at the University of Groningen in the Netherlands and his colleagues created PigeonBot II. The design includes 52 real pigeon feathers and a bird-like tail – and test flights have been successful.

Lentink says the secret to PigeonBot II's success is in its programmed reflexive tail movements, designed to mimic those known to exist in birds. If you hold a pigeon and tilt it from side to side or back and forward, its tail automatically reacts and moves in complex ways. This has long been thought to be the key to birds' stability, but now it has been proven by the robotic replica.

PigeonBot II, a robot designed to mimic the flying techniques of birds

The researchers programmed a computer to control servomotors in Pigeonbot II. These steer the craft using propellers on each wing, but also automatically twist and fan the tail in response, creating the stability that would normally come from a vertical fin. Lentink says the reflexive movements are so complex that no human could directly fly Pigeonbot II. Instead, the operator issues commands to an autopilot, telling it to turn left or right, and an onboard computer determines the right control signals. After many tests to refine the system, Pigeonbot II was finally able to take off, cruise and land safely (*Science Robotics*, doi.org/g8rjt7).

"Now we know the recipe of how to fly without a vertical tail. Vertical tails, even for a passenger aircraft, are just a nuisance. It costs weight, which means fuel consumption, but also drag – it's just unnecessary drag," says Lentink. ▮

Matthew Sparkes

Geophysics

Carbon may have helped Earth's iron core solidify

James Dinneen

A SPRINKLING of carbon in Earth's inner core could explain a mystery about how the deepest part of our planet solidified.

The inner core presents a paradox: it formed as a massive liquid ball of mostly iron, then began to solidify within the past billion years. For that process to start in a pure iron object, it would have had to cool by at least 700 kelvin in that time period, which seems impossibly fast given how big the core is.

Alfred Wilson at the University of Leeds, UK, and his colleagues have now simulated the cooling of the inner core if another element was involved. The core mostly consists of iron and nickel, but about 10 per cent is made up of an unknown composition of lighter elements like silicon, sulphur, oxygen and carbon.

The researchers used a supercomputer to simulate the interactions of iron and carbon atoms under the high pressure and temperature conditions of the inner core (EarthArXiv, doi.org/ns8z). With carbon atoms making up about 15 per cent of the non-iron and nickel mix, solid clusters of atoms started to form with as little as 250 K of cooling, a plausible temperature change in roughly a billion years, says Wilson.

Wilson says a more complex simulation – including oxygen – might reveal a scenario where the inner core could solidify with even less cooling. ▮

The inner core of our planet is a hot, dense ball of mostly iron

ROSTISLAV/SHUTTERSTOCK

Zoology

Wild cavefish can somehow survive with almost no sleep

Michael Le Page

VPC ANIMALS PHOTO/ALAMY

JENNIFER IDOL/STOCKTREK IMAGES/ALAMY

Cave-dwelling populations of Mexican tetras (left) barely sleep, while river-living types (below) snooze for several hours a day

SLEEP is thought to be vital for the health of animals including us, but one kind of cave-dwelling fish can manage without it. It appears to be healthy despite this, with a normal lifespan.

Alex Keene at Texas A&M University first observed more than a decade ago that some fish from cave-inhabiting populations of the Mexican tetra (*Astyanax mexicanus*) seem to barely sleep. "Some sleep a little bit," says Keene. "A lot of the fish sleep zero hours."

One issue with these previous studies is that they involved specimens kept in the lab. Now, with the help of researchers in Mexico, Keene has shown that these cavefish barely sleep in the wild, too.

Most *A. mexicanus* live in rivers outside caves and have normal vision and some colouration. There are also more than 30 populations living in caves that have partly or totally lost their eyes and colour.

Keene's team caught fish from four populations of surface-dwelling fish outside caves, six populations of cavefish and five populations of intermediate forms. The surface fish were found to sleep between 3 and 6 hours per day, based on their activity levels, whereas the cavefish and intermediate forms barely slept.

The team then confined some surface and cavefish in netted enclosures in their natural habitat, and saw that each group exhibited the same behaviour as before. The study also shows that this ability to go without sleep has evolved independently on at least three occasions (bioRxiv, doi.org/ns8w).

> **"There is something about these caves that is pushing the animals to adapt not to sleep"**

"The next step is clearly to record brain activity and look at how that's different between surface fish and cavefish," says Keene.

Brainwave recordings have shown that some birds sleep briefly during long flights. Sometimes only half of their brain sleeps at a time, as is also the case in some whales. While it is possible that the cave tetra is swimming while asleep, says Keene, it isn't clear why it would need to when surface fish don't. Yet the fact that the sleeplessness trait has evolved independently on at least three occasions suggests there is an important reason for it.

"There has to be something about these caves that is pushing the animals to rapidly adapt not to sleep," says Keene. One suggestion is that they have to spend more time looking for food.

Another possibility is that they have evolved the equivalent of such sensitive hearing that even the slightest noise keeps them awake. Fish have lines along their sides that can detect vibrations, and Keene's team has previously shown that, in cavefish, these lateral lines are extremely sensitive and that their output appears to be involved in suppressing sleep.

It is a wonderful study, says Robert Kozol at St. John's University in New York, who also studies *A. mexicanus*. "It provides strong evidence that near-total sleep loss is a common and convergent cave adaptation," says Kozol. ▮

Physics

Einstein's theories tested on the largest scale ever – and he was right

Karmela Padavic-Callaghan

ALBERT EINSTEIN'S theory of general relativity has passed a test on the largest scale yet. An analysis of millions of galaxies shows that the way they have evolved over billions of years is consistent with his predictions.

Ever since Einstein put forward his theory of gravity more than a century ago, researchers have been trying to find scenarios where it doesn't hold up. Now, Mustapha Ishak-Boushaki at the University of Texas at Dallas and his colleagues have used data from the Dark Energy Spectroscopic Instrument (DESI) in Arizona to run such a test at the level of the largest distances in the universe.

Details of cosmic structure and how it has changed are a good test of our understanding of gravity because it was this force that shaped galaxies as they evolved out of variations in the distribution of matter in the early universe.

DESI has so far collected data on how nearly 6 million galaxies clustered over the course of 11 billion years. Ishak-Boushaki and his colleagues combined this with results from other large surveys, such as those mapping the cosmic microwave background radiation and supernovae. Then, they compared this with predictions from a theory of gravity that encompassed both Einstein's ideas and more contemporary competing theories of modified gravity. They found no deviation from Einstein's gravity.

40m
galaxies will be surveyed by the DESI project

Ishak-Boushaki says that even though there are some uncertainties in measurements, there is still no strong evidence that any deviations from Einstein's theory would capture the state of the universe more accurately.

Itamar Allali at Brown University in Rhode Island says it is crucial to be able to test general relativity at all scales to eliminate the possibility that Einstein made correct predictions for objects of one size but not another.

The new analysis also offers hints for how dark energy, a mysterious force thought to be responsible for the accelerating expansion of the universe, fits into our theories of gravity, says Nathalie Palanque-Delabrouille at Lawrence Berkeley National Laboratory in California.

Einstein's earliest formulations of general relativity included a cosmological constant – a kind of anti-gravitational force that played the same role as dark energy – but previous DESI results have suggested that dark energy isn't constant. It may have changed as the universe aged, says Palanque-Delabrouille.

Seeing agreement with general relativity and this departure from the cosmological constant really opens the Pandora's box of what the data could be telling us, says Ishak-Boushaki.

DESI will keep collecting data to record the properties of 40 million galaxies, which should clarify how to marry general relativity and theories of dark energy.

Allali says these results may be consequential in many ways, such as pinpointing shifts in the Hubble constant – a measure of the rate of the universe's expansion – narrowing down the mass of particles called neutrinos and revealing new cosmic ingredients like "dark radiation".

"This analysis will weigh in on a lot more than gravity, it will weigh in on all of cosmology," he says. ▮

Marine biology

Heart-shaped mollusc has windows in its shell

A MOLLUSC has evolved tiny windows that work like fibre-optic cables, the first known example in nature.

Heart cockles (*Corculum cardissa*) are bivalve molluscs a bit like clams that have a symbiotic relationship with photosynthetic algae that live inside them. The algae have a safe home, get light to photosynthesise and provide nutrients for their hosts.

Unlike other bivalves, heart cockles don't open their shells up wide, so it wasn't known how they funnelled light to the algae inside.

Now, Dakota McCoy at the University of Chicago and her colleagues have found that there are transparent calcium carbonate crystal structures in heart cockle shells that function like fibre-optic bundles, letting light inside to bathe the algae. "If you don't have to open and can just have a transparent window, that's a very safe way to irradiate your algae," says McCoy.

The researchers examined fragments of different heart cockle shells and the transparent structures within them, as well as the intensity and colour of light that gets through.

They discovered that the windows were made from long, thin fibres of a mineral called aragonite – a form of calcium carbonate – which lets twice as much photosynthetically useful light through as it does harmful ultraviolet light (*Nature Communications*, doi.org/ns8s).

DAKOTA MCCOY

A heart cockle shell illuminated to show its stripe-like windows

"We put on sunblock because UV causes mutations and cancer. The heart cockles are using these windows as a sunblock," says McCoy.

The transparent windows were of various shapes, including small triangles and long stripes.

While the aragonite threads look similar to manufactured fibre optics and transmit light just as effectively, they lack a protective, insulating sheath, called cladding. This could serve as an inspiration for cladding-free fibre-optic cables, which would be cheaper to manufacture.

The natural, UV-blocking properties of the shells could also be used to help protect corals, which, like the cockles, host photosynthetic algae inside them, but are more susceptible to environmental stresses like light and heat, says McCoy. ▮

Alex Wilkins

Space travel

Astronaut thinking slows in space

Effects on working memory and processing speed could be a problem for future missions

Alex Wilkins

ASTRONAUTS on the International Space Station (ISS) had reduced memory, attention and processing speed after six months, raising concerns about the impact of cognitive impairment on future space missions to Mars.

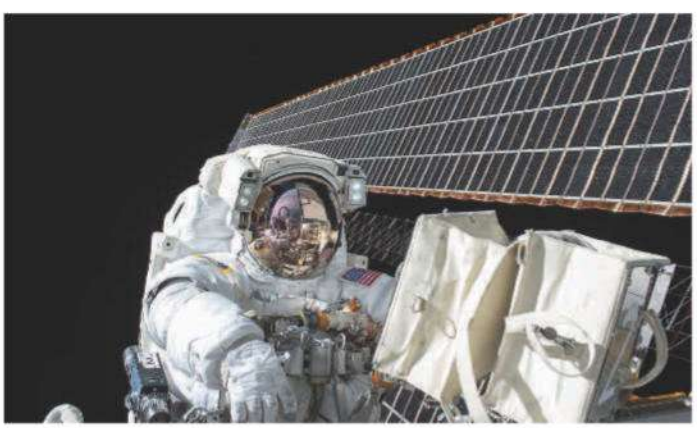
The extreme environment of space, with reduced gravity, harsh radiation and the lack of regular sunrises and sunsets, can have dramatic effects on astronaut health, from muscle loss to an increased risk of heart disease. However, the cognitive effects of long-term space travel are less well documented.

Now, Sheena Dev at NASA's Johnson Space Center in Houston, Texas, and her colleagues have looked at the cognitive performance of 25 astronauts during their time on the ISS.

The team put the astronauts through the same set of 10 tests both on Earth and on the ISS. These were repeated once before, twice during and twice after the mission, within 10 and 30 days of landing. The tests measured cognitive capacities, such as finding patterns on a grid to gauge abstract reasoning or choosing when to stop an inflating balloon before it pops to test risk-taking.

The researchers found that the astronauts took longer to complete tests measuring processing speed, working memory and attention on the ISS than on Earth, but they were just as accurate. While there was no overall cognitive impairment or lasting effect on the astronauts' abilities, some measures, like processing speed, only returned to normal some time after they came back to Earth (*Frontiers in Physiology*, doi.org/ns8p).

When you are working in space, there is a lot to keep track of



NASA

Having clear data on the cognitive effects of space travel will be crucial for future human space flight, says Elisa Raffaella Ferrè at Birkbeck, University of London, but it will be important to collect more data, both on Earth and in space, before we know the full picture.

"A mission to Mars is not only longer in terms of time, but also in terms of autonomy," says Ferrè. "People there will have a completely different interaction with ground control because of distance and delays in communication, so they will need to be fully autonomous in taking decisions, so human performance is going to be key. You definitely don't want to have astronauts on Mars with slow reaction times, in terms of attention-related tasks or memory or processing speed."

"You definitely don't want to have astronauts on Mars with slow reaction times"

It isn't surprising that there were some specific decreases in cognitive performance given the unusual environment of space, says Jo Bower at the University of East Anglia in Norwich, UK.

"It's not necessarily a great cause for an alarm, but it's something that's useful to be aware of, especially so that you know your limits when you're in these extreme environments," she says. ▮

Ecology

Giant hornet from Asia appears in Europe for first time

SOUTHERN giant hornets, a species native to Asia, have been sighted in Europe, raising concerns about their potential impact on native insects.

Between 2022 and 2023, Omar Sánchez Fernández at the University of Oviedo, Spain, and his colleagues found four giant hornets in wasp traps in Asturias, Spain. Genetic analysis revealed that these four female workers were southern giant hornets, *Vespa soror* (*Ecology and Evolution*, doi.org/ns8r).

"Although beekeepers in the area had told us that they had seen strange hornets, it was a surprise to discover this species," says Sánchez.

Southern giant hornets are usually found in warmer parts of Asia, in countries such as China, India and Thailand. The workers are up to 35 millimetres long and the queens can reach 46 millimetres. They hunt invertebrates such as butterflies, grasshoppers, bees and other wasp species, but also small vertebrates like geckos.

Another Asian species, the yellow-legged hornet (*Vespa velutina*), is now widespread across most of Europe, having first arrived two decades ago. Its impact as a predator of honeybees and native bees is a concern, with the economic cost in France alone estimated at over €30 million a year.

RUSHEN

Southern giant hornets are normally found in countries like China, India and Thailand

While the sting of southern giant hornets isn't pleasant, and is probably a bit worse than Europe's native hornet species, they aren't really more dangerous to humans, says Benjamin Taylor at Purdue University, Indiana. "They're not super aggressive unless they're approached," he says.

Sánchez and his colleagues suspect the species reached Spain as a stowaway in a shipment and don't think it is widespread in the area. ▮

Gennaro Tomma

Astronomy

Planet 10 times the size of Earth is one of youngest ever found

Jonathan O'Callaghan

A WORLD seen orbiting a 3-million-year-old star about 520 light years from Earth is one of the youngest known planets, offering a window into early planet formation.

The star is an early-stage dwarf star, one much dimmer and less massive than our sun. Its age has been estimated by comparing the intensity and wavelengths of the light it emits with other stars.

Madyson Barber at the University of North Carolina at Chapel Hill and her colleagues studied the star using NASA's Transiting Exoplanet Survey Satellite (TESS). They found a planet about a third of the mass of Jupiter and 10 times the diameter of Earth by noticing the dip in the star's light as the planet passed in front.

The world's mass and size suggest it is either a large rocky planet, known as a super-Earth, or a small gas giant, called a sub-Neptune, in the process of formation.

We think Earth took between 10 million and 20 million years to form, about 4.5 billion years ago, says Barber. "So it was kind of surprising to see anything at 3 million years."

The system is also notable for still having its protoplanetary disc of dust and gas, meaning the star and planets are still in the process of taking shape, although that disc is oddly misaligned out of the plane of the system (*Nature*, doi.org/ns8m). "We're not super sure what caused the misalignment," says Barber. "It's possible a stellar flyby happened as the system was forming."

The planet is extremely close to its star, completing an orbit every nine days, which is also puzzling as it is unclear whether planets can form in such proximity. They can move inwards over time, as is thought to have taken place in our solar system when some of the giant planets jostled for position. "It hints at fast migration of planets being a thing," says Barber. ▮

Health

Fat cells have 'memory' of obesity that may drive yo-yo dieting effect

Carissa Wong

PEOPLE with obesity who lose weight often put it back on, which may partly be driven by lasting changes to the DNA within their fat cells, a discovery that could one day lead to new treatments.

About 85 per cent of people who are overweight or obese and lose at least a tenth of their body weight regain it within a year. That is partly because it is hard to maintain low-calorie diets for a long period of time, although that probably plays a relatively small role, says Laura Catharina Hinte at the Federal Institute of Technology Zurich in Switzerland. "It can't be that we all don't have enough willpower to maintain lost weight."

Studies have also shown that the brain interprets a sharp drop in body fat as dangerous and

"It can't be that we all don't have enough willpower to maintain lost weight"

responds by making the body burn less energy. To learn more about this process, Hinte and her colleagues analysed fat tissue collected from 20 people with obesity just before they had bariatric surgery, which shrinks the stomach to make people feel fuller sooner, and again two years later, when they had lost at least a quarter of their initial body weight. They also looked at fat tissue taken from 18 people with a healthy weight.

The researchers analysed which genes were making proteins in fat cells and found differences in the activity of more than 100 genes when comparing cells from people with obesity and people of a healthy weight, and these differences persisted at two years after weight loss.

DRAZEN_/GETTY IMAGES

These changes seem to ramp up inflammation and disrupt how fat cells store and burn fat, both of which raise the risk of future weight gain, says team member Ferdinand von Meyenn, also at the Federal Institute of Technology Zurich.

To explore whether these genetic changes might drive rebound weight gain, the researchers first confirmed that similar changes persisted after obese mice lost weight. They then fed these mice, along with mice of a healthy weight, a high-fat diet for one month. While the previously obese mice gained 14 grams of weight, on average, the other mice gained just 5 grams (*Nature*, doi.org/g8rc5t).

The team also found that fat

5g

was gained by healthy-weight mice eating a high-fat diet

14g

was gained by previously obese mice eating the same food

If you manage to lose weight, it can be hard not to put it back on again

cells from the previously obese mice took up more fat and sugar when grown in a lab dish than those from the other mice. Together, the results show how obesity-linked genetic changes may increase future weight gain, says von Meyenn.

Finally, the team found that molecular tags on DNA in the fat cells seemed to drive the obesity-linked changes to genetic activity. This is an example of epigenetics, where the way genes work can be changed by their environment.

The study didn't look for these molecular tags in the people they studied, or examine whether they regained the weight they lost. However, based on the similarities between the physiology of these species and how the environment influences their genes, the findings probably translate from mice to humans, says Henriette Kirchner at the University of Lübeck in Germany.

In the decades to come, drugs that target epigenetics could help treat obesity, she says. ▮

EMERGENCY TRAUMA CARE

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An MSF surgical team at Al-Shifa's burn unit in Gaza city cleans the wound of a child after a burn injury.
Photograph © Tetiana Gaviuk/MSF

DR JAVID ABDELMONEIM IS AN MSF DOCTOR RECENTLY RETURNED FROM WORKING IN GAZA.

"At Nasser hospital, we provide trauma surgery and burns care to patients. One Saturday early in my time there, we received hundreds of injured, as well as people who had been killed, following a missile strike.

It was chaos. Our team went to the emergency room. One of the injured was a three-year-old girl. She was breathing and looking at me – so she must be okay, I thought. But as I rolled down her dressing, I found that her entire left thigh was open to the bone.

Seconds later, the doors crashed open. Four to five injured people were brought in, most of them first-aid responders. Among them was a boy who wasn't breathing, so we tried to revive him, but the nurse looked at us and asked: 'Why are we responding to him if he can't breathe? We have to save other lives.' No one had the heart to call it and move on to the next person. He was someone's child. But we had to move on to the next, and then the next, and this continued for another four and a half hours.

In the emergency room, there was blood all over the floor. I had to kneel to see the patients, who were sprawled everywhere because there were no beds left. At the same time, more and more patients were coming in.

EVERY SECOND COUNTS

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Views

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Culture Emily H. Wilson's top five science fiction reads of 2024 p30

Comment

A helping hand

Don't be fooled by Elon Musk's chatty Optimus robots. The long history of robotics should teach us to be more sceptical, says **Nicole Kobie**

OPTIMUS robots wandered around the party held after Elon Musk's Tesla unveiled its robotaxi last month, doling out drinks and chatting with guests. They were also being photographed, as android butlers make for great social media content. Partygoers couldn't believe their eyes – and they shouldn't have. The robots weren't fully autonomous, but remote-controlled avatars.

That shouldn't have surprised the tech-savvy revellers. After all, when Musk first unveiled Optimus in 2021, the humanoid robot that strode onto stage was actually a costumed dancer. Indeed, throughout the long history of robots, if one impresses with its intelligence, it's a safe bet it is an avatar or carefully programmed.

ELAINE KNOX

The very first humanoid robots were hulking metal androids – and used similar tricks to those at Musk's party. Eric was made in 1928 by William Richards to deliver a speech at the Exhibition of the Society of Model Engineers. It couldn't walk, but could gesticulate and turn its head.

Most impressively, Eric could converse, and was interviewed by journalists. Richards didn't reveal how, but implied the magic was managed via radio: Eric was less a metal ancestor to Alexa and more an overengineered walkie-talkie.

Subsequent robots have gained further skills, notably in the late 1960s, when the research institute now known as SRI International built the remarkable Shakey, which could navigate and make decisions. More recently, Boston Dynamics helped develop robots that walk, and though it prefers four-legged designs, a military contract sparked the creation of the bipedal Atlas, its humanoid robot that climbs, flips and runs in videos, but is only just starting to shift into commercial applications.

Boston Dynamics' robots have embedded intelligence that lets them walk and dodge obstacles without human help, but even they aren't fully autonomous. In 2020, the company posted a video of Atlas dancing to the song *Do You Love Me?* – but that took three months of programming.

Autonomous humanoid robots have been built, but remain limited. The best known is perhaps Pepper, developed by Aldebaran after it was acquired by SoftBank. It glides on wheels, its smooth, white, plastic form mimicking the curves of a nipped-in waist and skirt, a control tablet on the front. Released in 2014, Pepper made headlines, finding work as a receptionist, even reading funeral rites. But it failed to find purpose – it couldn't empty your dishwasher or use a vacuum cleaner – so production was halted in 2021.

Start-ups like Figure and Agility continue the work towards a general-purpose humanoid robot, but arguably we don't need robots that look like us. Legs may be more useful than wheels to move around without replacing every staircase with ramps, but four is easier for balance than two, hence "dog" style robots like Boston Dynamics' Spot, already in use for monitoring and maintenance.

Indeed, there were more than 4 million industrial robots in use globally as of 2023 and millions more robots autonomously vacuum our floors. Yet they aren't shaped like us: why automate a human to hoover your home when a Roomba is cheaper and needs less space in the cupboard?

One day, we may have the choice: home automation through a network of smart appliances or a single robot butler. But in the meantime, when a humanoid robot struts up for a chat and a drink, by all means be impressed – but, until proven otherwise, assume it is an avatar or is heavily programmed. When a general-purpose, autonomous, bipedal robot truly does arrive, tech firms won't be shy about letting us know. After all, Musk held a press conference to announce Tesla was starting work on robotics. Imagine the theatrics if his firm actually produces a real robot butler. ▮

Nicole Kobie is a journalist and the author of *The Long History of the Future*

This changes everything

How to build a better world

John "Bud" Benson Wilbur isn't often remembered today, but this forgotten civil engineer had a vision of the future we could all learn from, says **Annalee Newitz**

Annalee Newitz is a science journalist and author. Their latest book is *Stories Are Weapons: Psychological warfare and the American mind.* They are the co-host of the Hugo-winning podcast *Our Opinions Are Correct*. You can follow them @annaleen and their website is techsploitation.com

Annalee's week

What I'm reading
Untethered Sky *by Fonda Lee, the tale of a badass warrior and her giant attack bird.*

What I'm watching
I'm checking out @coyoteyipps, or Janet Kessler, who has been photographing urban coyotes in San Francisco for almost two decades.

What I'm working on
Some essays on the history and future of futurism.

This column appears monthly. Up next week: Rowan Hooper

YOU have probably never heard of John "Bud" Benson Wilbur, but he is a low-key civil engineering legend. In the mid-20th century, he was chair of the civil and sanitary engineering department at the Massachusetts Institute of Technology (MIT). He built some major bridges in Massachusetts and helped prototype the first wind power systems in Vermont. But I first encountered his work in a silly-but-serious essay called "Whither civil engineering?", published in the March 1952 issue of *The Technology Review*. In it, Wilbur claimed he and his colleagues had invented a crystal ball for seeing the future called the Paynterscope.

The Paynterscope, Wilbur wrote, revealed the distant-future world of 1977. Africa had become a Wakanda-like paradise full of farms, clean rivers and high-tech systems for weather control and water management. The US was criss-crossed with conveyor belts for rapidly transporting freight, while roads were surfaced with a sustainable, durable version of rubber, making the infrastructure more resilient. A transit tunnel whisked cars below the English Channel (yes – he predicted the Chunnel). There were dozens of other gee-whiz inventions, but most of them were like these: improvements to old, bog-standard tech to help humans stay comfortable and healthy.

At one point in his essay, Wilbur described his co-authors using the Paynterscope to peer into the future waterways of the US. They exclaimed happily: "Don't those streams and lakes look fine? No more pollution!" By the 1970s, they imagined that engineers would have figured out how to treat sewage quickly and cheaply.

Wilbur's humble, self-satirising style of futurism is a stark contrast with our current era, where cutting-edge engineering projects are generally pitched as ways to maximise profit for corporations and optimise or eliminate human labour. Wilbur's vision shows us science serving the public good.

He spent most of the 1950s working with a colleague at MIT, Robert Hansen, on designs for bombproof buildings that could withstand the blast of an atomic weapon. Wilbur made joking reference to this in his article, describing looking through the Paynterscope to see how many of their buildings survived into the 1970s. To his surprise, he discovered that few were in existence and that it "appeared atomic warfare was no longer a major consideration".

"In Wilbur's distant-future vision of 1977, a transit tunnel whisked cars below the English Channel"

Wilbur concluded that this, too, could be credited to good civil engineers: by the 70s, he imagined that advances in civil engineering would have increased sustainable energy and food supplies, improved the environment and created resilient public transport to distribute resources globally. "All of these activities had contributed directly to a higher standard of living throughout the world, and thus had helped to remove one of the major causes of war," he wrote. Living in the aftermath of war, Wilbur wanted to build a better world – literally – using resource abundance to steer people away from violent conflict.

Interestingly, Hansen wrote his own futurist essay for *The Technology Review*, years later in 1967, where he suggested a different solution to resource scarcity: using genetic engineering to create "small man", tiny people who used less food and energy. This idea, often referenced in sci-fi, became notorious as an example of odious futurism, focused on controlling people's bodies instead of making it easier for them to thrive in the bodies they have.

Unfortunately, a lot of futurism today sounds more like Hansen's "small man" essay than Wilbur's fanciful musings. Venture capitalists, who are essentially economic futurists, are hyping artificial intelligence with the promise of shrinking human creators down to nothing. Silicon Valley's billionaire leaders are investing in separatist, libertarian "network states" run on cryptocurrency, while neighbouring areas experience housing shortages and drought.

Wilbur's long-forgotten essay offers us a different way of thinking about what comes next. The mind-blowing engineering achievements of tomorrow could involve cleaning up the environment and making healthcare, housing and transport work brilliantly for everyone.

In the 1960s, Wilbur retired to Woodstock, a village on the border of New Hampshire and Vermont. He lived there until his death in 1996 and stayed active by creating a summer programme for civil engineering students who wanted to try their hands at solving real-world problems in an actual town.

For Wilbur, good engineering offered the promise of a healthy life, without war, on a planet with clean water and plentiful food for the public. It isn't glamorous, and it probably wouldn't get the big venture capital money. But it might just help us build a better world. ▮

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Paradise lost

Photographer: Matilde Gattoni

THE world's oases are at the forefront of an existential battle against climate change: limited rainfall and rising heat have dramatically affected these unique ecosystems and the culture they sustain. Morocco has lost two-thirds of its oases – lush, fertile areas in the desert – in just a single century.

Take the town of M'Hamid El Ghizlane, the last stop before the vast, dry expanse of the Sahara. Here, local people plead with the desert for water (near left, top). Dressed in white robes, they regularly meet at the edge of the desert to recite ancestral chants asking for an end to the drought and for life to be brought back to the land.

While droughts have always been part of life here, they used to be intermittent, allowing people to stock food and water to make it through dry times. But the oasis that sustains the community has shrunk over the past few decades, leading to scorched palm trees and threatening centuries of culture and tradition.

The town's economy has traditionally been sustained by date palms (far left, top) and camel herding (far left, bottom), but with those livelihoods in jeopardy, many are relocating to nearby cities. Those who remain often earn a living through tourism. Former farmers turned self-taught guides offer visitors desert expeditions and tea ceremonies (near left, bottom) – a glimpse of the life that persists despite the challenges.

Matteo Fagotto

Editor's pick

Prospects of colonising the Red Planet are truly dire

16 November, p 48

From Todd Bailey, Penarth, Vale of Glamorgan, UK

Kelly and Zach Weinersmith consider challenges to living on Mars. Fictional futures sometimes improve the Martian climate by moving the planet closer to the sun, but the more I learn, the less plausible these scenarios seem.

Back-of-the-envelope calculations suggest that moving Mars into Earth's orbit would require energy equivalent to three full days of the sun's total output. If we could afford at some point in the future to devote one year's worth of global energy production to the task, at the current rate of growth we will have to wait for 12 trillion years. I won't be holding my breath.

From Nick Canning, Coleraine, County Londonderry, UK

I fear Mars would be a dreadful destination for colonising for all the reasons stated, plus the planet-wide dust storms that would kill any hope of photosynthesis for periods and interrupt solar power. And what about surviving the maddening isolation? At least on the ISS one can look out of the window at the beauty of Earth below and imagine all the other life with which we share the planet. Mars isn't just hostile, but lethal, a place for which we have no evolutionary adaptation.

Here's why Shackleton wreck is so pristine

Letters, 16 November

From John Shears, Expedition leader, Endurance22

Reader Gerald Legg asks why the wreck of Ernest Shackleton's ship Endurance, found at the bottom of the Weddell Sea in Antarctica, looks so good.

There are several reasons. The cold water temperatures (-1.8°C; 28°F), total darkness, low oxygen and lack of sedimentation, together with the ship's strong wooden construction, have all contributed to preserve the ship. But the most important reason for the lack of decay is the absence of any shipworms. These bore into and eat wood in other oceans and destroy wooden shipwrecks, unless the timbers are covered rapidly by mud and sediments. Shipworms aren't found in the Weddell Sea as the water is too cold for them to survive and there is no wood for them to eat.

Those fascinated by Endurance can read more about its incredible condition in the book *Endurance: The discovery of Shackleton's legendary ship*, by me and my colleague Nico Vincent.

Let's also hear it for the Bamboo Age

9 November, p 32

From Hugh Morgan, Hartfield, East Sussex, UK

Your article "The Botanic Age" gives welcome space to the subject of pre-Stone Age advances. It would seem important to also mention the Bamboo Age. Bamboo is nature's fast growing construction material and it can be modified to make anything from a knife to a source of ignition, cooking pot or twisted thread. It is also a lightweight but structurally supreme material to build a raft, boat or major construction.

From Martin Murray, Telford, Shropshire, UK

As a hobby willow-basket maker, I have often observed that no tools are required. A sharp knife is useful, but not necessary. Likewise, textiles and grass-fibre baskets require no tools to create.

The notion that early humans or prehumans waited for stone tools to be invented before developing other technologies is absurd. Our ancestors were smart enough to weave baskets, shelters, blankets and so on from plant fibres and sew hides with plant fibres with no durable tools required. On a cold night, a crude blanket is better than none.

Soil decline is a major threat to future farming

16 November, Leader and p 44

From Fred White, Nottingham, UK

Neither your article on the impact of food production on the planet nor the editorial that accompanied it mentions the health and maintenance of the largest biome bar the ocean: soil. It is unlikely that wheat yields could increase by 18 per cent by 2100 if farmers keep doing what they are doing unless you could coax a crop from something that will, by then, resemble Martian regolith. A healthy soil structure is essential, if nothing else, for management of water retention and drainage.

On closer inspection, myopia is a mixed bag

16 November, p 40

From Margaret Woodhouse, Tirphil, Caerphilly, UK

As a myope and optometrist, I find the term "disease" for myopia misleading. Axial length of the eye is a continuum; people whose eyes don't grow long enough have hypermetropia/long-sight. No one says this is a disease, but it also requires spectacle correction.

From Maggie Cobbett, Ripon, North Yorkshire, UK

When it comes to myopia, there is a mystery that has long plagued me. After illness kept me at home for a few days, I returned to school to find I could no longer make out writing on the blackboard. A lifetime of spectacles and contact lenses to correct "short-sightedness" ensued. My mother always insisted it was scarlet fever that damaged my eyes, but others have pooh-poohed the idea, saying it was more likely to have been measles. I would like to know one way or the other.

From Geoffrey Mann, Bookham, Surrey, UK

Myopia isn't all bad news. Reading small print or seeing fine detail is easy even as an adult, when this acuity can otherwise fade. Perhaps an evolutionary advantage arose after fine craftsmanship became an essential survival skill.

See the moon in all its globular glory

16 November, p 52

From Tim Nichols, London, UK

For most of my life, my brain rendered the moon as a flat disc or crescent in the diamond-studded canvas of the night sky. However, I discovered that if I think of the moon as spherical while I look at it, it pops out that way. Instead of a flat object, I see it for what it is: a 3500-kilometre-wide globe floating beside us in space and considered by some a twin planet rather than a satellite.

Could clothes be why dogs bite faces of dead owners?

16 November, p 29

From Bob Denmark, Garstang, Lancashire, UK

On the issue of whether grief motivates a pet dog to bite the face of a dead owner, I have seen a few human bodies that have been partly eaten by animals. I suspect most target the face because it isn't clothed and there are easy routes to the soft interior, such as eyes, ears, nose and mouth. I doubt whether emotions play much part. Domestic pets may have more complex motivations, but clothing may be a factor for them, too. ▮

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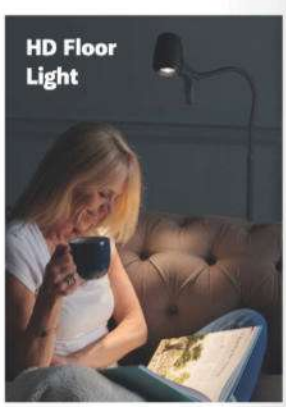

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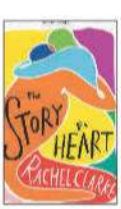
From Mars to the oceans, our immune systems to the sex lives of plants, *New Scientist* staff and writers pick their favourite popular science books of the year

***The Burning Earth* by Sunil Amrith**
This year hasn't been a great one for the environment, so a book about the long history of environmental damage may be a hard sell. However, this isn't just a litany of woe. It unpicks the ways environmental harms have been driven by social systems and individual mentalities. In doing so, it points the way to a better society: one that no longer wages war on nature. *Michael Marshall*

***Our Moon* by Rebecca Boyle**
Earlier this year, I brought *Our Moon* along on a trip to see that moon eclipse the sun. There are plenty of books about the moon, some grounded in science and others in poetry. Boyle's combines both, weaving science, history and archaeological exploration into a lyrical portrait of the relationship between all life on Earth and its satellite. I felt that kinship with our moon when I watched it slowly block out the light and bring on the eerie hush of totality. *Sophie Bushwick*



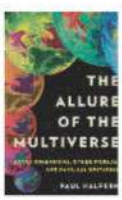
***The Story of a Heart* by Rachel Clarke**
This is the tale of 9-year-old Max, in desperate need of a heart transplant, and Keira, a 9-year-old girl left with catastrophic injuries after a car crash and whose parents agreed that she would have wanted to be an organ donor. With great compassion, Clarke tells both of their stories in the lead up to the transplant of Keira's heart that will save Max's life. Also a history of the innovations that led to heart transplantation being possible, this book is beautifully written and completely heartbreaking, a testament to the generosity of the human spirit in the face of unbearable grief. *Alison Flood*

DAVID TROOD/GETTY IMAGES

Intense: Find a quiet spot and expand your mind with these inspiring books

***Unlocked* by Pete Etchells**
There is plenty of heat and precious little light in the debate around whether social media and smartphones are bad for young people. It is why, in a world where we are increasingly regulating based on vibes, I recommend this book. Etchells is a realist, shying away from the easy analogies of dopamine hits and drug-like addiction and sticking to the science. Too often, "scientifically rigorous" means "boring", but not in Etchells's hands. The prose is pure pop science, but unlike many such books, it is rigorously researched. *Chris Stokel-Walker*

***Coming of Age* by Lucy Foulkes**
Teenagers work in mysterious ways. Or do they? In this book, psychologist Foulkes calmly reveals the rules and reasoning that drive many adolescents to behave the way they do. Punctuated by case study interviews, it is a deeply personal reminder of what it is like to go through this life change – and that while everyone has their own tale, there are common threads that unite them all. This is reassuring not only to parents, but also to the many adults who have been left hurt, confused or otherwise marked by their teenage experiences. *Catherine de Lange*



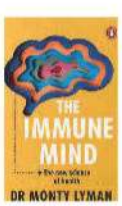
***The Allure of the Multiverse* by Paul Halpern**
For the past few years, pop culture has been obsessed with parallel worlds and alternate timelines – so thank God for a physicist's handy guide to the real science behind the mind-bending concept of the multiverse. Halpern explains why ideas like the many-worlds interpretation might answer some of the biggest questions in physics. He is an entertaining writer with a knack for untangling tricky concepts and theories, while never shying away from the complexities that attract so many to this area of science. *Bethan Ackerley*

***Your Face Belongs to Us* by Kashmir Hill**
This is an excellent account of facial recognition tech and what it is doing – and will do – to our lives. In rollercoaster style, Hill tells the story of her investigation into Clearview AI, a facial recognition platform with a claimed 98.6 per cent accuracy rate, as she digs into its origins, is fobbed off and gets to know the company's shadowy founders. A thrilling story with a frightening message about the inroads artificial intelligence is making into our lives. *AF*

***Nuclear War* by Annie Jacobsen**
Laying out, minute by minute, what would happen if North Korea launched a nuclear missile at the US, this is meticulously researched

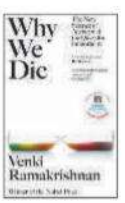
through interviews with military experts and scientists – and utterly terrifying. How would the US react to the attack? How would Russia react to the US's reaction? Is there any way for the world to survive? Not in this scenario. This pick for our New Scientist Book Club should be a must-read for all. *AF*

***Systemic* by Layal Liverpool**
This is a thought-provoking and, at times, shocking book by Layal Liverpool, who used to work at *New Scientist*. Opening with the disparity in maternal mortality rates between Black and white women in the US, it lays out how health is harmed by pseudoscience and racial bias, from assumptions about higher pain thresholds that can be traced back to experiments on enslaved people to the controversial use of "race adjustments" in some medical test results. Interviews and personal anecdotes bring humanity to the studies and statistics, ensuring this has an emotional as well as scholarly heart. *Eleanor Parsons*



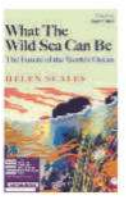
***The Immune Mind* by Monty Lyman**
I am fascinated by the human body and how each cell, tissue and organ works in tandem. Nowhere is this biological frontier more prevalent than when it comes to neuroimmunology, or the study of how the brain and the immune system interact. Lyman unravels this remarkable connection. He delves into how an overreactive immune system can contribute to mental health conditions, how the mind can make us more susceptible to infection and the ways in which we can strengthen our body's defence system. It is one of the best popular health books I have read in the past few years. *Grace Wade*

***Supremacy* by Parmy Olson**
It is undeniable that the world changed in November 2022 with the launch of ChatGPT, though we are still wrestling with whether it was for good or ill. If you want to know how we got to this moment, look no further than this deeply reported book. Olson follows the story of OpenAI's Sam Altman and DeepMind's Demis Hassabis on the road to developing their AI products, with fascinating insights along the way. *Jacob Aron*



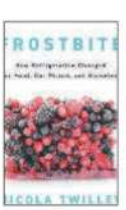
***Why We Die* by Venki Ramakrishnan**
The Nobel laureate asks why we age in the first place, and looks into the cutting-edge science that is being done to extend the human lifespan. As someone who "works in molecular biology, but has no real skin in the game" when it comes to research on ageing, he is the perfect guide to this booming area, also interrogating the important question of what it will mean for us all if people start living longer. *AF*

***Not the End of the World* by Hannah Ritchie**
Amid the climate gloom, Ritchie provides a ray of hope, arguing that we are far from doomed. From climate change to air pollution, we know how to solve almost all of the world's most pressing environmental challenges. In many cases, change is well under way. This is a deliberately upbeat take on a huge problem and Ritchie's enthusiasm for the challenge is infectious. *Madeleine Cuff*



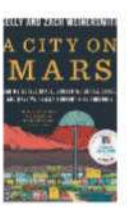
***What the Wild Sea Can Be* by Helen Scales**
Starting half a billion years ago, when Earth's waters were full of trilobites, Scales tells the story of our oceans and the animals that live there, from orcas to emperor penguins. Scales writes like a dream and makes an impassioned call to protect our seas and coastlines, inviting readers to share in her love for the oceans. As she puts it: "Living together on this blue planet, we are all ocean people." *AF*

***The Light Eaters* by Zoë Schlanger**
If you were looking for a book celebrating the extraordinary powers of plants, look no further than this. If you weren't looking for such a book, you really ought to be. Plants can learn and memorise information, they can summon predators to come to their aid, they can communicate with each other. And don't get me started on their sex lives – there is enough variation and intrigue in plant sex to satisfy anyone. Plants, you will learn from this expansive and beautiful book, have a form of intelligence, even consciousness, that, until recently, we would have been unwilling to even consider. *Rowan Hooper*



***Frostbite* by Nicola Twilley**
I am obsessed with the hidden world of supply chains and logistics, so this book was a real treat. Twilley details how the chilly tendrils of refrigeration infiltrated the world to transform both our diets and our societies – well, at least in richer nations, because the benefits of cold aren't evenly distributed. You will learn the history of keeping food cold, which started as an expensive novelty viewed with suspicion by the masses, along with what it takes to work in the Arctic temperatures that keep our food fresh. *JA*

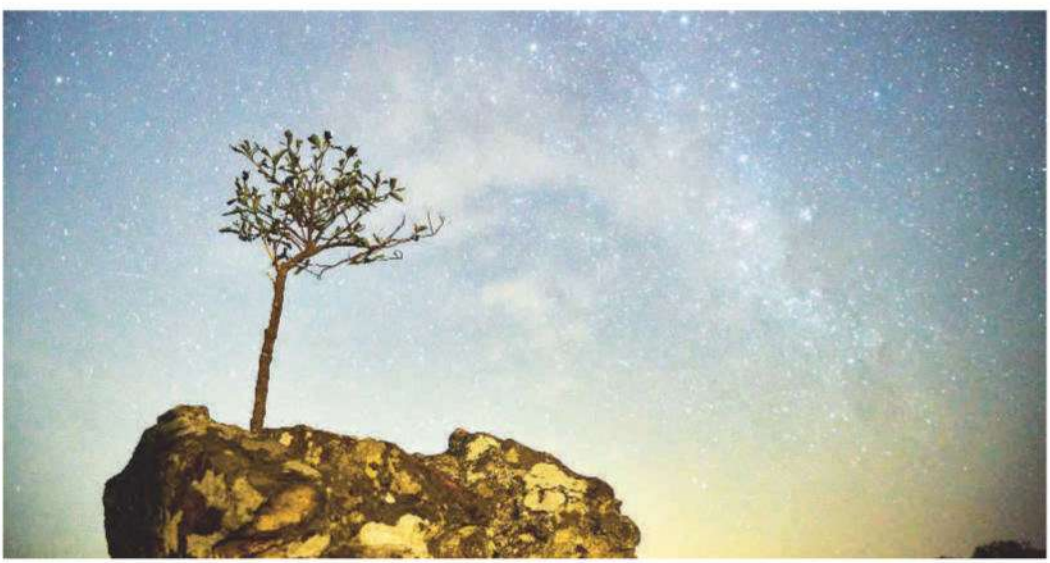
***Selfish Genes to Social Beings* by Jonathan Silvertown**
As an evolutionary biologist, I was raised on a diet of selfish genes and cutthroat competition. But life is much more than that. It is about cooperation and symbiosis as much as it is about fighting and cheating. This book restores cooperation to its rightful place in the evolutionary story. Cooperation is still driven by selfish genes, from the origin of life to the evolution of complex ecosystems. Fascinating and timely, this is a survey across all of biology – a history of ideas – and it tells how the story of life is one of teamwork from the gene level upwards. *RH*



***A City on Mars* by Kelly and Zach Weinersmith**
I judged the Royal Society Trivedi Science Book Prize this year, and the Weinersmiths's hilarious and brilliant look at the reality of living on Mars was our winner. The authors lay out all the reasons why a Martian colony would be a bad call, from the complexities of having space kids, to just how awful life would be as an indentured worker on Mars. They even make space law fascinating. And there are cartoons! *AF*

Other worlds than this

Murder in space, a sexbot, a dystopian vision of the future: our science fiction columnist **Emily H. Wilson** picks her top five reads of 2024



MATT MAWSON/MILLENNIUM IMAGES, UK

2024 has been a great year for sci-fi, from time travel stories to those set in space

IT HAS been a good year for science fiction, with a novel set on the International Space Station winning the 2024 Booker prize. *Orbital* is a beautiful, sublimely written, hopeful book that takes place over 16 orbits of Earth.

One might argue that it isn't science fiction. After all, the ISS is a real place and the book is simply a novelisation of ordinary life upon it. Author Samantha Harvey describes it as "space pastoral". But then what is or isn't sci-fi is an argument that will rumble on forever (see below) and so I am claiming *Orbital* and its Booker win for Team Science Fiction.

That novel actually came out last year. So what about the new sci-fi in 2024? I have read a great deal of it in order to find books to recommend to you.

That said, I haven't read every piece of sci-fi published this year, so the list below is already a less than fully rigorous exercise. To add to that, reading a book is an extremely subjective experience. Anyway, here, unscientifically, subjectively, is my list of the five best sci-fi novels out this year (that I have read).

***Juice* by Tim Winton**

This book is a heavyweight piece of work from a much-admired novelist. It imagines life in Australia in a few centuries' time, post-climate collapse. *Juice* is what is now known as "climate fiction", but it could also be called dystopian or speculative. Whatever: it is a vision of life in the far future, an examination of blame and retribution after the end of the world as we all now know it, and also a gripping yarn.

***Creation Lake* by Rachel Kushner**

Like *Orbital*, this story, involving an undercover operative infiltrating eco-activists, isn't really science fiction. I think a better description of it would be "a novel of ideas masquerading as a spy caper". However, it is also arguably climate fiction and has a lot of palaeoarchaeology in it. It somehow wound up on sci-fi lists this year and then in the New Scientist Book Club.

At a *New Scientist* creative writing weekend in the Brecon Beacons, UK, earlier this month,

"*Juice* is a vision of life in the far future, an examination of blame and retribution after the end of the world"

the distinguished author Adam Roberts (mentioned again below) claimed that sci-fi is only sci-fi if it plays around with big ideas, i.e. it has to push the thought envelope in some fashion. So a story set in space that could as easily be set on Earth wouldn't count as sci-fi. But then Roberts also, in the same lively discussion, claimed that all fiction is science fiction. On the basis of that second claim, then, I will add (the completely brilliant) *Creation Lake* to this list. Regardless of genre, it is a wonderful work of literature.

***The Other Valley* by Scott Alexander Howard**

Now this is a book that really does play with big ideas. It is a time travel thriller where if you move between valleys in the world of the novel, you travel backwards and forwards in time. It is beautifully written, original and masterfully plotted, and I have found myself thinking back on it many times this year.

***Annie Bot* by Sierra Greer**

This underrated book is an exploration of artificial intelligence, freedom of will, abuse in relationships and lots more. It is a tightly drawn, at times very funny, portrait of a relationship between a second-rate human and his first-rate sexbot, Annie Bot.

***Lake of Darkness* by Adam Roberts**

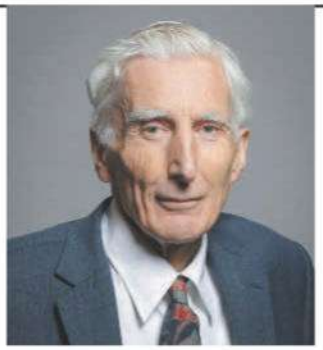
This is a bold novel of ideas set in a space-travelling future. Two spaceships turn up to study a black hole, but then one of the ships' captains starts to believe he is communicating with something inside it. But how can that be? Shortly afterwards, this scientific mystery shifts to the back burner when the captain begins killing his crew. Has he been contaminated by something in the black hole?

Roberts, who is also a professor of 19th-century literature, sets out to do something different with each of his novels. In his author's note at the end of *Lake of Darkness*, he explains that the book is influenced by philosopher Gilles Deleuze and that it follows on (intellectually) from his Kantian novel, *The Thing Itself*, and his Hegelian novel, *The This*. I am going to have to take his word for all that, but regardless, this is a really interesting piece of work from a great author. ▮

Emily H. Wilson is the author of the *Sumerians* trilogy, set in ancient Mesopotamia

RSA

From mapping the mysteries of black holes to shaping international science policy, Sir Martin Rees, Lord Rees of Ludlow, is a renowned British astrophysicist and cosmologist.



First joining as an RSA Fellow forty years ago, Sir Martin is best known for his pioneering work in galaxy formation and the structure of the universe. Having served as the Astronomer Royal, President of the Royal Society and currently a member of the House of Lords, we asked Sir Martin to share why the RSA Fellowship remains close to his heart and continues to inspire him.

Why are building connections important?

Curious about the power of professional networking in the science world, we asked Sir Martin Rees for his view. He emphasised the importance of establishing new connections as being "very important at all levels." He stressed the incredible value of building new friendships through professional societies and thought-provoking events like RSA's lectures and gatherings.

Championing diversity

From Sir Martin's perspective, the RSA Fellowship can cater to a wide range of individuals: "The Fellowship is very varied. I can imagine it is especially valuable for retired academics who are living in the country", he explained. For Sir Martin, living in Cambridge gives him the advantage of constant academic interaction. He acknowledged how, for those "retired to some small town where there is no immediate contact with people in their field", the RSA's community provides an invaluable opportunity for engagement. He went on to highlight how those in more remote locations "benefit hugely from these networks locally like Zoom" or, in person.

The RSA provides an enriching space for individuals to share ideas, grow professionally, and make long-lasting positive impact. As Sir Martin's experience shows, the Fellowship truly embodies a diverse, supportive, and forward-thinking community that benefits people at all stages of their lives.

The RSA Fellowship is open to everyone over the age of 18, and we actively welcome new voices and perspectives. We believe in building a diverse and dynamic community, so if you're interested in joining, the application process is straightforward and accessible to all.

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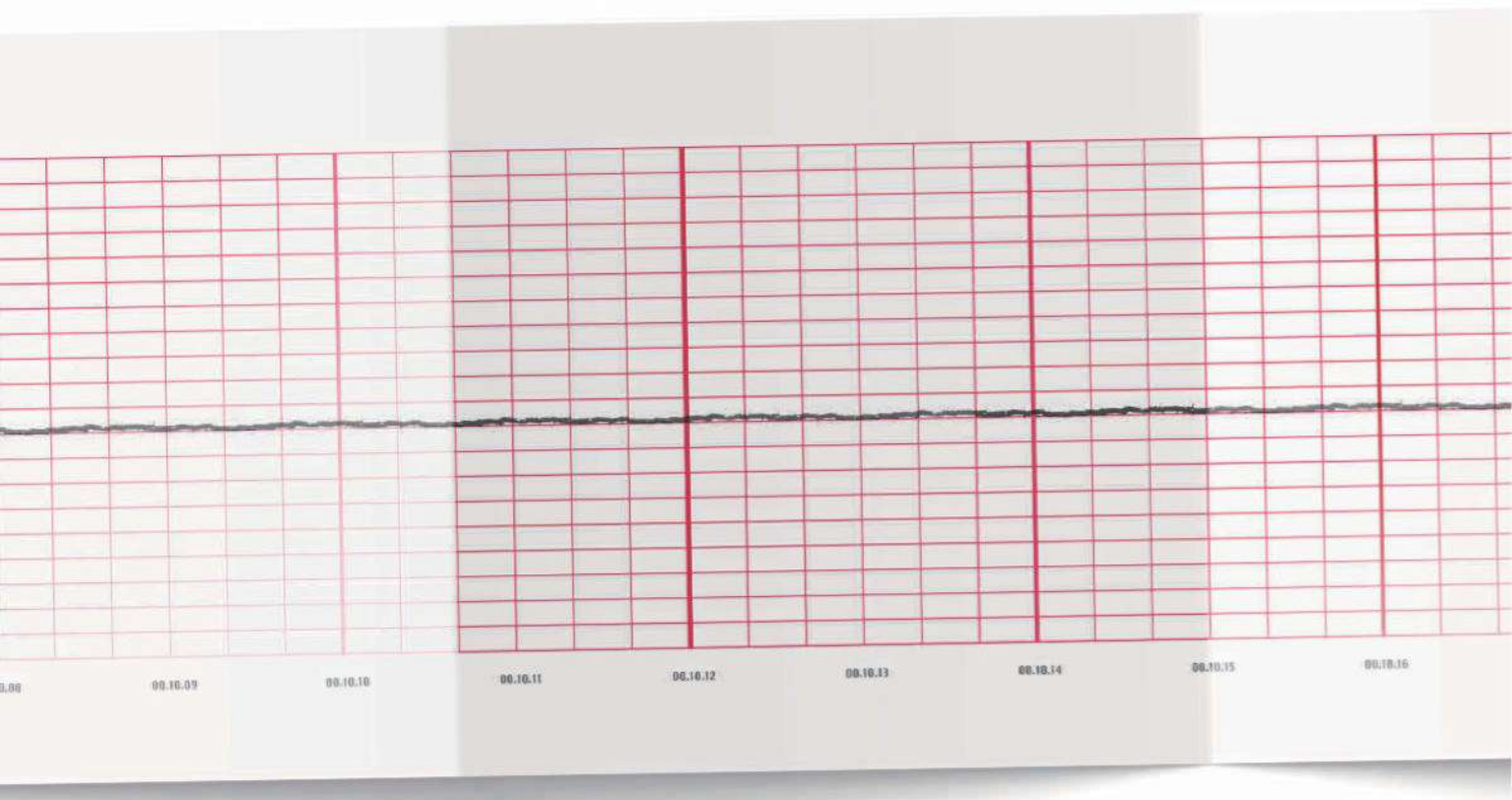


Back to life

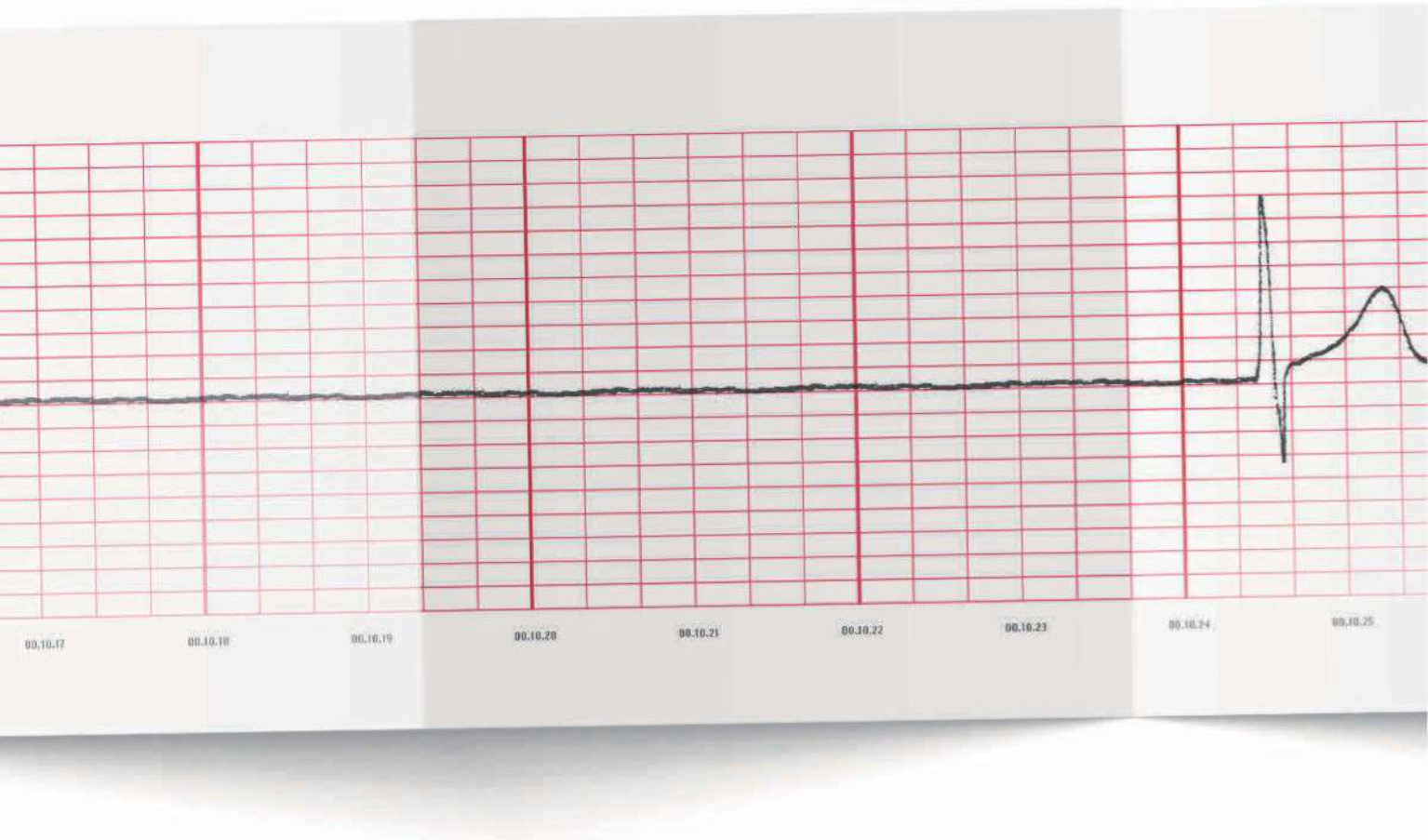
Surprising experiments that have reanimated brains and other organs suggest death could in fact be reversible. **Helen Thomson** investigates

THE severed pig's head had come from the local abattoir. It would have typically been discarded, but Zvonimir Vrselja, a neuroscientist at Yale School of Medicine, and his colleagues had other ideas. Four hours after this particular animal was decapitated, they removed its brain from its skull. They then connected the dead brain's vasculature to tubes that would pump a special cocktail of preserving agents into its blood vessels and turned the perfusion machine on.

That was when something incredible happened. The cortex turned from grey to pink. Brain cells started producing proteins. Neurons juddered back to life, displaying signs of metabolic activity indistinguishable from that of living cells. Basic cellular functions, activities that were supposed to irreversibly cease after blood flow stopped, were restored. The pig's brain wasn't alive, exactly – but it certainly wasn't dead.

Now, for the first time, the team is using the technique on human brains.

"We are trying to be transparent and very careful because there's so much value that can come out of this," says Vrselja. Reanimating – in a sense – a dead human brain would have tremendous medical benefits. Researchers



KOLOTUSCHENKO/ISTOCK

could trial drugs on cellularly active human brains, leading to improved treatments. Similar techniques are already being used to better preserve other human organs for transplants, too. And in what is perhaps the most immediately useful application, the resuscitation technology involved raises the possibility of saving people on the cusp of death.

The problem is that it is an ethically complicated undertaking, to put it mildly. And by demonstrating the brain's extraordinary resilience, this work forces us to ask, when is a person really dead?

Vrselja and his colleagues' work on pigs' brains sent shock waves through the medical community five years ago. "When I heard, my first reaction was 'holy shit!'" recalls Hank Greely, a biomedical legal expert at Stanford University in California. He wasn't alone. The idea that a brain cut from a body, deprived of oxygen and kept at room temperature for 4 hours could be revived "goes against everything we thought we knew about death", says Lance Becker at the Feinstein Institutes for Medical Research in New York. "We're at a real paradigm-shifting moment as we redefine what is life and what is death."

Deciding when someone is dead has never been as easy as you might think. Ancient Greeks used cessation of breathing as a sign of death, holding a candle near the mouth to check. Later physicians confirmed death by trying to shock a presumed dead person into life – putting their finger to a flame or poking them with needles. In the early 1800s, after several publicised cases of supposed premature burials, mortuaries and hospitals kept corpses for several days to confirm putrefaction; canny inventors started patenting "safety coffins" with air tubes and bells that could be rung from the inside.

These days, people are typically declared dead when their heart stops beating – known as cardiac arrest – and cannot be restarted. The UK doesn't have a legal definition of death, instead accepting medical opinion. In the US, on the other hand, doctors in most states rely on the Uniform Determination of Death Act to define death, which states that an individual is dead once "they have sustained either irreversible cessation of circulatory and respiratory function or the irreversible cessation of all functions of the entire brain, including the brain stem".

The key word here is "irreversible". Until recently, we thought we knew two things for sure about death. First, that when your heart stops beating, the electrical activity in the brain ceases within seconds to minutes. Second, that the brain suffers irreparable damage within 5 to 10 minutes of the onset of oxygen deprivation. But recent studies have upended both of these assumptions.

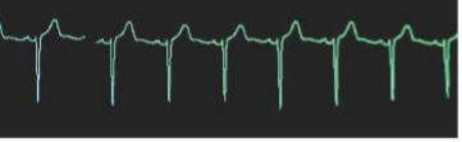
Let's start with the notion that electrical activity in the brain diminishes after cardiac arrest. For a study published in 2023, Jimo Borjigin, a neuroscientist at the University of Michigan Medical School in Ann Arbor, and her team analysed brain activity from four dying people before and after the withdrawal of their life support. "Rather than decreasing in activity, the whole brain appeared to be on fire," says Borjigin.

In two of the people, brain regions that were silent while the person was on life support suddenly fizzed with activity after it was withdrawn. High-frequency brainwaves called gamma waves, a hallmark of consciousness, also burst into action. Synchronised activity resembling the kind associated with memory and perception lasted for up to 6 minutes. Some brain areas suddenly tried to strike up conversation with the heart. These waves of activity dampened, then ›

intensified three times; in some areas, the activity was 12 times greater than before the individual's heart had stopped beating and they were no longer breathing. "The dying brain actually starts this massive rescue effort," says Borjigin. "If we can better understand what's going on at this point, I believe we could resuscitate it."

Because the people involved didn't survive, it is impossible to know what they experienced in those last moments of frenzied brain activity. But the study confirmed that this boundary between life and death isn't black and white – and it isn't the only study to do so.

> **"We're at a real paradigm-shifting moment as we redefine life and death"**



MIGUEL SOTOMAYOR/GETTY IMAGES

"We're all conditioned to think of death as this binary thing," says Sam Parnia, a cardiopulmonary researcher at New York University. "You're alive and then you're dead. Most people aren't willing to accept that biology doesn't work that way." In 2023, his team recorded brain activity in 53 people who were being resuscitated after a cardiac arrest. Despite almost all of the patients flatlining – meaning their brain activity was silent – 40 per cent later showed spontaneous brain activity associated with consciousness during resuscitation attempts, sometimes up to an hour after their heart had stopped. Parnia's team spoke to some of the people who survived, as well as others in the local community who had experienced a cardiac arrest, and found that 20 per cent recalled a conscious experience that occurred during the time in which their heart had stopped.

Although some question Parnia's findings, the study nevertheless demonstrates that something is happening at the point of death. "You can't talk about the dying brain without thinking about the nature of consciousness," says Parnia. And it isn't just the dying brain that is making us question our understanding of life, death and consciousness. The dead brain is raising questions, too.

We had good reason to believe that the brain couldn't survive more than 10 minutes without oxygen: trying to revive a person after that deadline is rarely successful and those that survive often experience cognitive problems. However, though oxygen deprivation does initiate cell death, the damage that follows has less to do with the brain not receiving oxygen and more to do with what happens when it is restored. When oxygen-rich blood suddenly starts pumping around a body and brain that have experienced ischaemia, or lack of oxygen, this sudden reintroduction causes what are known as reperfusion injuries.

Perfecting perfusion

Friedhelm Beyersdorf at the University of Freiburg, Germany, likens it to a broken leg. "If I break my leg and someone helps me to stand, they don't tell me to walk immediately, because my leg needs treatment," he says. "It's the same with our organs. Once they go without oxygen, they are damaged. You can't just pump blood back in and expect them to work as before – they need to be treated first."

To prevent reperfusion injuries in his pig brains, Vrselja and his colleagues developed a cocktail of drugs that target the pathways that typically lead to damage after ischaemia. This included molecules that balance cell pH, drugs that prevent an excessive immune response and antibiotics. They modified a dialysis-type machine designed to keep other organs alive outside of the body. Their device, called BrainEx, could perfuse this cocktail through the brain's arterial network in a pulsating fashion, at just the right pressure to penetrate cells, while also clearing waste products.

It worked. Four hours after decapitation, the brains were plugged into BrainEx and revived – albeit not to the point of consciousness. In their 2019 paper, Vrselja and his co-authors were quick to note that they didn't observe brain activity associated with perception. Indeed, they had made sure this didn't happen by ending the experiment after 6 hours and including sedatives in their cocktail that inhibited electrical activity.

Repeating the experiment on a donated human brain, however, requires a greater level of assurance: if there were any evidence of consciousness-like brain function, that would raise the question of whether you are experimenting on a live person, and what rights they then deserve. "That's very tricky ethically, legally and scientifically," says Greely.

JONATHAN NACKSTRAND/AFP VIA GETTY IMAGES

L: SHUTTERSTOCK/JAROMIR CHALABALA; R: CARL

Vrselja and his colleagues are treading extremely carefully, noting that they have a broad group of bioethicists and legal and medical experts advising them. "We had to develop new methods to make sure no electrical activity is occurring in an organised way that might reflect any kind of consciousness," says Vrselja.

For now, they aren't using this technology to attempt to restore consciousness to a dead human brain. Instead, Vrselja and his team are keeping brains cellularly active for up to 24 hours to test treatments for conditions such as Alzheimer's and Parkinson's. It is hard to develop drugs for neurological conditions, says Vrselja, because current methods for testing them are insufficent. "That's why the field is riddled with mystery – often we don't even know if a drug can get into the brain," he says. "Now we can address that. It's research that's going to make a real difference to humans."

Top left: An ECMO machine temporarily takes over heart and lung function after cardiac arrest.

Bottom left: Improving CPR could save lives.

Below: CARL is the next generation of resuscitation technology.

Vrselja acknowledged, however, that others may attempt to resurrect dead brains in a greater capacity. Trying to bring a brain back to life, consciousness and all, would be nothing less than an attempt at immortality, says Greely. "A living brain in a box seems to me like hell rather than life, but people pay a lot of money to have their heads cryogenically frozen with highly implausible chances of reanimation. I'm a little surprised no quack has tried selling this service yet – as far as I know."

A grey zone

If bringing back an already dead brain is a tantalising if ethically sensitive prospect, Vrselja's research also suggests we could intervene in brains and bodies on the brink of death. Though he and his colleagues have no intention of plugging anyone at the point of death into their BrainEx machine, they want to use their new knowledge about resuscitation to help save human lives.

In 2022, they developed a similar system, called OrganEx, to perfuse a blood-based cocktail through a whole pig 1 hour after its heart had stopped beating. They found that the reperfusion therapy reduced cell death in various organs and restored function in the pig's brain, heart and kidneys. The heart began to contract, the brain resumed metabolising and several genes associated with cellular repair were switched on. The pig even started to make involuntary movements, despite being anaesthetised.

Similar technology is now being trialled to keep human organs alive for transplant. When a person is pronounced dead, they are attached to a version of OrganEx, with the arteries leading to the brain clamped so that it is shut off from the system. In doing so, organs stay alive for much longer, giving them more time to get where they are needed. "There is a tenfold number more donors than kidney recipients, yet there is a huge waiting list because we can't get the organs to where they need to be," says Vrselja. "This can really help save a lot of lives."

Meanwhile, reperfusion technology is already helping keep more people alive after injury. Researchers at the University of Freiburg, led by Beyersdorf, and German technology company Resuscitec spent more than a decade developing "controlled automated reperfusion of the whole body", or CARL, which is a modified version of a heart-lung bypass technology called extracorporeal membrane oxygenation, or ECMO. While ECMO temporarily takes over heart and lung function by circulating and cleaning a person's blood after cardiac arrest, CARL goes further, perfusing the body with a cocktail of haemoglobin – the oxygen-carrying protein in blood – and 13 other components that protect organs from ischaemic damage. It also features two pumps that replicate the pulsing motion of the heart, helping the cocktail reach all areas of the body and brain.

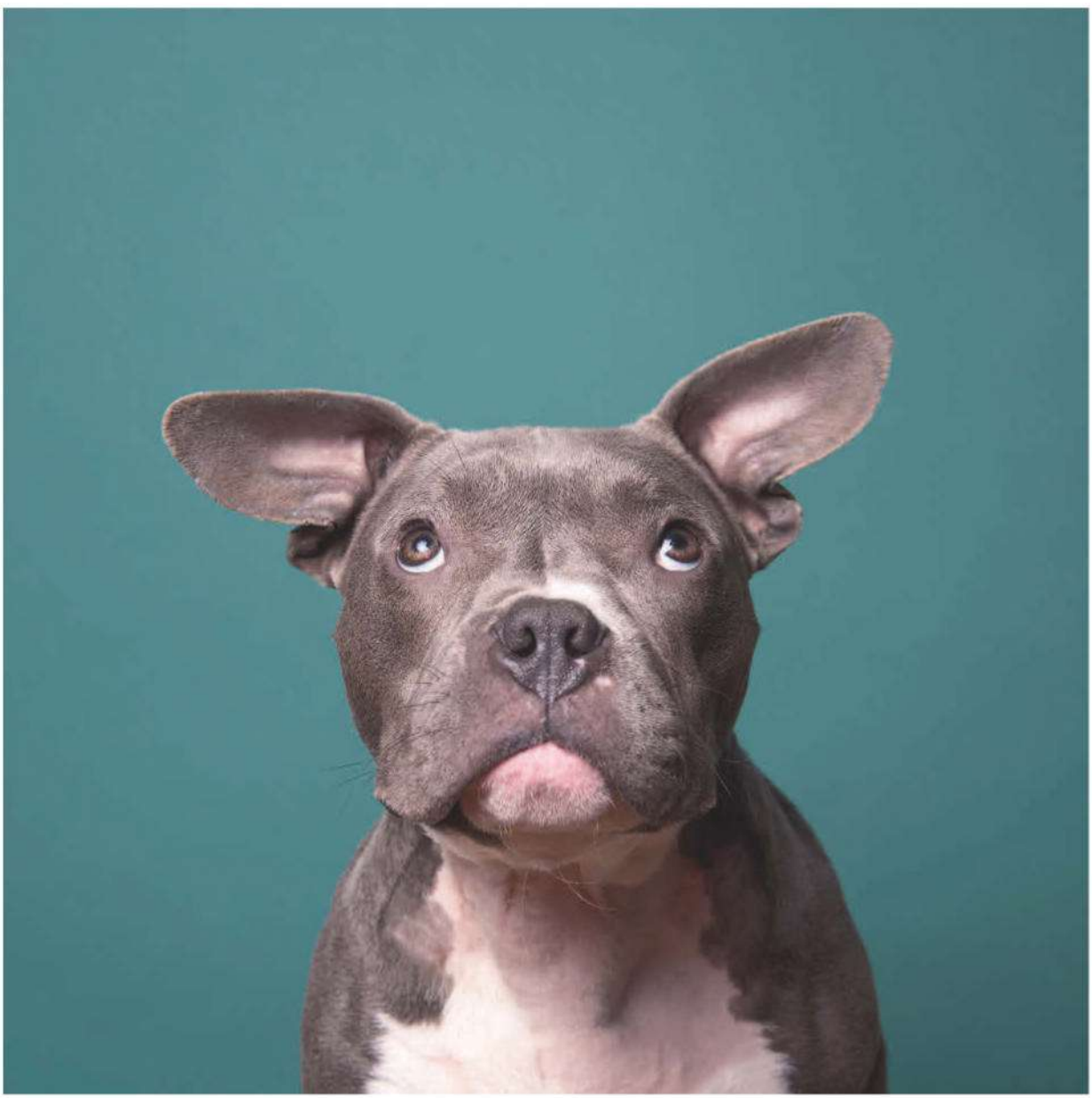
Early trial results are promising. Typically, only about 1 in 10 people who experience a cardiac arrest survive. But in a trial run by Beyersdorf, CARL was given to people whose hearts had stopped and who had received CPR for around an hour; of these, 42 per cent survived and 79 per cent of those had normal cognitive function. Early results from another trial of CARL in Germany, in people whose hearts stopped outside of a hospital, showed that it revived five of the first 10 people treated. Resuscitec brought CARL to market in Europe in 2023 and is awaiting FDA approval in the US.

Our greater understanding of the moments after cardiac arrest and the possibilities of restoring life is blurring the line between dead and not dead. "It used to be straightforward to pronounce a patient dead," says Becker. "I could safely say with confidence that their heart had irreversibly stopped. Now, it's more 'they're dead, nudge nudge, wink wink'." By that, he means that while they are dead because the treatments available at that moment can't save them, he can't be sure that they are irreversibly dead. "If we had the right people in the room, the right machines, I know that the heart and brain might be revived," he says. "So are they really dead?"

At the moment, that question remains unresolved. "As CARL is used more widely, we'll see how long our organs can survive without oxygen," says Beyersdorf. "And then perhaps we'll have to change our definition of death."

For now, we are in a grey zone. "It will take a while, but the field of resuscitation is going to advance so that people who are routinely diagnosed as dead today are not viewed that way any longer," says Becker. "That's a pretty remarkable rewriting of human existence." ▮

Helen Thomson is a London-based journalist and author of *Unthinkable: An extraordinary journey through the world's strangest brains*



SOPHIE GAMAND

Good dog!

A unique project is revealing science-based ways you can train your dog to behave better, finds **Colin Barras**

"OREO was my best friend growing up," says Brian Hare. If Hare wanted to hone his baseball pitching skills, his labrador enthusiastically took on fielding duties. If he decided to explore the nearby woods, Oreo was an ever-willing companion. But there was one place where boy and dog always parted company. "Oreo never set foot in our house. Not one time," says Hare.

Today, the front door is no longer closed to most dogs in higher-income countries – and many spend their days relaxing on sofas and watching TV. You would think they would be in doggy heaven. But Hare, an evolutionary anthropologist at Duke University in Durham, North Carolina, thinks the development has left them in the doghouse. For millennia, he says, we expected dogs to guard our property and protect our family at nighttime. Now, we have a different set of expectations. Not only do we want our indoor dogs to be friendly around strangers and rest quietly through the night, they should also respond to potty training, refrain from chasing other animals and keep their dirty feet off the upholstery. "It's an evolutionary mismatch," says Hare.

The good news is that this problem is solvable. A glut of recent studies indicate that selective breeding and careful training can help dogs adapt to indoor life. Meanwhile, Hare and his team have set up a "puppy kindergarten" in their lab to drill down into the behaviours required and shed new light on dogs' cognitive developmental milestones. Better yet, the researchers have devised techniques that owners can use right now to help train their pets and build better relationships with them.

Despite the challenges that indoor life poses for many canines, we know that dogs can adapt astonishingly well to it, because some already have. Service dogs – which are usually labradors, golden retrievers or crosses of the two breeds – can pull wheelchairs, open doors and operate light switches. They also display extraordinary levels of self-control and are gentle when interacting with children. "In terms of behaviour, they are the dogs that most dog owners want," says Vanessa Woods, also at Duke University, who works alongside and is married to Hare. "They're about a century ahead of other dogs."

Service dogs have achieved these heights through a decades-long programme of selective breeding for temperament, combined with intensive training. If other breeds are to emulate them, researchers first need to tease apart the relative importance of these two factors. That is one thing Hare and Woods have been trying to do. Since they opened the doors of their puppy kindergarten six years ago, they and their colleagues have put more than 100 puppies through their paces. The dogs, all of which come from service dog breeding programmes, live at the facility between the ages of about 8 and 20 weeks. There, they are lavished with attention and repeatedly tested on a series of game-like tasks. This helps establish what service dog behaviour looks like before intensive training begins, while also showing how it changes in the first weeks of life as their brains develop.

This unique research programme is the subject of a book by Hare and Woods called *Puppy Kindergarten*, which was published earlier this year. One thing they have discovered is that individuals' behaviour varies markedly. At 8 weeks of age, for instance, puppies can typically understand pointing and similar visual communicative gestures. However, while one named Yolanda aced every test of this ability, her brother, Ying, repeatedly flunked the same tests. By about 10 weeks, meanwhile, a typical service dog puppy begins to develop basic self-control. Again, some puppies, including one called Aries, quickly mastered the skill. Others, such as the unusually energetic Weston, did not.

A potential explanation for this variation came about a year after the puppy kindergarten project began, when Gitanjali Gnanadesikan at Emory University in Atlanta, Georgia, and her colleagues, including Hare, published research exploring the heritability of behavioural traits in dogs. They collected data from some 1500 dog owners on the behaviour of their pets, which belonged to 36 breeds, including border collies, standard poodles and Siberian huskies. By comparing this with publicly available information on the genetics of each breed, the researchers discovered that genes aren't destiny when it comes to dog behaviour. After controlling for differences in training history, genetics explained 45 per cent of the variation in canine self-control, just 16 per cent of the variation in reasoning about the physical world – understanding, for example, that a treat-shaped lump in a cloth indicates that a treat is hidden beneath it – and a mere 0.01 per cent of the variation in short-term memory. "Genetics is important, but its relative importance is different for different behavioural traits," says Gnanadesikan – and for all the traits in question, heritability is too low to guarantee that the trait will be present in every puppy in a litter.

That said, the findings also show that some desirable behaviours are heritable to a certain degree, which confirms that selective breeding for temperament is worthwhile. Some dog breeders are already aware of this, but many may not be. Service dogs and other working dogs aside, behaviour certainly doesn't appear to have been a particular focus of selective breeding efforts in recent centuries. Hare and Woods suspect this reflects the rise of dog shows. The first of these was held in Newcastle upon Tyne, UK, in 1859 and reportedly saw the top prizes go to dogs that happened to be owned by two of the competition judges. Quickly, dogs began to be judged primarily on their looks, and breeders started to make physical features the focus of their selective breeding efforts. "People shaped dogs to be all of the different forms that we celebrate today," says Hare. "But I don't think there was much intentional selection for behaviour."

Change is finally in the air, however. In ›

New Scientist video
Watch more on the science of dog behaviour
youtube.com/newscientist

FRANK ARMSTRONG/ALAMY

2020, behavioural biologist Jessica Perry Hekman founded the Functional Dog Collaborative, a nonprofit group that is attempting to shift the culture around dog breeding. The aim, she says, is to encourage more breeders to produce companionable pet dogs. To help meet that aim, her organisation has linked up with the Companion Dog Project, a group of breeders who are now beginning to focus on producing dogs with a temperament to meet the expectations of modern pet owners. "There are, of course, already many people who breed for the pet market," says Carolyn Kelly, the group's director. "But our mission is to set a standard of quality for this type of breeding."

So far, only around 40 breeders across the US have signed up to the project, and Kelly is unaware of similar initiatives in other countries, so we can't expect the behaviour of our pets to change dramatically any time soon. Besides, as the puppy kindergarten work illustrates, selective breeding cannot guarantee desirable traits – even in service dogs. There is, however, emerging evidence of more immediate ways we can help dogs develop the behaviours we now prize.

One potentially promising route is through diet – an approach that builds on recent interest in the idea that the human gut microbiome influences our cognitive performance. A study published earlier this year found that dogs with a good memory tend to carry a bacterium called *Bifidobacterium pseudolongum* in their gut microbiome. The research is at a very early stage, says team member Lucia Lazarowski at Auburn University in Alabama. Nevertheless, if follow-up studies find a causal link between *B. pseudolongum* and dog memory, it may be possible to develop dietary supplements loaded with these microbes to boost canine memory performance.

"For millennia, we expected dogs to guard our property and protect our family"

What makes this particularly enticing is that a good memory is a highly desirable trait, while also being one that Gnanadesikan's research suggests is unlikely to be improved through selective breeding. "Memory, especially working memory, is considered a higher cognitive function that's important in everything that humans and animals do," says Lazarowski. "It is especially important in training." And, as the puppy kindergarten project has made clear, dog training is crucial to foster those behaviours we would like our pets to exhibit in our homes.

Look into my eyes

One habit that is especially important in training is making eye contact. It doesn't just underpin the extraordinary capacity of dogs to understand our visual communicative gestures, it also strengthens our relationship with them. Takefumi Kikusui at Azabu University in Sagamihara, Japan, and his team found that when dog owners make eye contact with their pet, they have increased levels of oxytocin, a hormone that boosts well-being and social bonding. "The dog's gaze may be a causal factor in inducing good feelings in the owner," says Kikusui – and the longer a dog gazes at its owner, the stronger those good feelings become.

One of the most surprising – but potentially important – findings from the puppy kindergarten project is the discovery that a simple training exercise can help dogs develop the habit of prolonged gazing. It involves one of the game-like tasks used by the researchers to assess cognitive development. A puppy is first allowed to retrieve and eat a treat resting in an open plastic container. A second treat is then placed in the container – but this time, the container's lid is snapped shut to make

Test your pooch

Researchers at Duke University in Durham, North Carolina, have devised a series of games to test the cognitive abilities of dogs. Here's a selection you can play at home to explore the intellectual strengths and weaknesses of your own pet.

WHILE your dog is watching, place two deep bowls behind a solid barrier. Show your pet a small treat, then go behind the barrier and put it into one of the bowls. Remove the barrier and point at the bowl containing the snack. A dog that reliably approaches the correct bowl understands your pointing gesture: it has good communication skills.

STAND a few metres from your dog and, while it watches, place a treat in one of two deep bowls. Distract your dog for 20 seconds with a fun toy, then allow it to approach the bowls. A dog that consistently chooses the bowl containing the treat has good short-term memory.

PLACE a metre-long, transparent plastic cylinder on the floor and drape a blanket across its centre. Show your dog a treat, then put it inside the cylinder. Allow your dog to retrieve the treat by reaching into an end of the tube. Now, repeat the exercise without the blanket. A dog that runs directly towards the centre of the cylinder – where the now visible treat lies – lacks self-control.

JARED LAZARUS/DUKE UNIVERSITY

it virtually impossible for the puppy to access the food. Hare, Woods and their colleagues found that by the age of about 12 weeks, some pups were beginning to learn that they could solve this "impossible task" by appealing to a human for help – and that the most effective way to make that appeal was through eye contact.

Then came the unexpected twist. Playing the game just a few times, with a two-week gap between each repetition, actually seemed to encourage puppies to make eye contact with humans more readily and maintain it for longer – 5.3 seconds, on average, compared with an average of 3.1 seconds in service dogs of a similar age that hadn't played the game repeatedly. "That was an amazing finding and one that I can't really explain," says Hare. He now recommends all puppy owners play the impossible task game with their pet for a few minutes every two weeks to strengthen the emotional connection between them.

More generally, Hare and Woods encourage dog owners and their pets to try as many of the task-like games from the puppy kindergarten as possible (see "Test your pooch", left). Doing so can help you learn where your dog's cognitive strengths lie, leading to a greater appreciation of your pet. "Your dog is probably doing all sorts of interesting things that you're not giving them credit for," says Hare. Whatever their individual talents, though, if you are trying to train a young dog, don't forget that, like children, their brains develop as they grow older. So, for example, your puppy is unlikely to respond to pointing before about 8 weeks, will struggle with self-control before 10 weeks and may only realise that it can seek your help at 3 months.

For anyone worried that this research implies dogs need constant care and attention to adapt to an indoor life, the puppy kindergarten work has one final message. They probably don't. True, the animals in the programme were given the very best start in life: they had daily exposure to dozens of new people and new experiences – far beyond anything that the average dog owner can provide. However, when the researchers compared the cognitive performance of these pampered pups with that of a cohort of service dogs raised without such a socially rich upbringing, there were few significant differences. "That amazed me," says Hare.

RYAN WILLS

Most dogs have been bred for good looks, not good behaviour

Recent research backs up this finding. Earlier this year, Stefanie Riemer at the University of Veterinary Medicine Vienna and her colleagues published a study that explored the emergence of human-directed gazing in puppies. Participants were puppies raised in standard homes, so lacking the social whirl experienced in the puppy kindergarten. Yet, when presented with a version of the impossible task game, some made eye contact with humans in an appeal for help at just 6 weeks of age – half the age of those in the lab. "They're already so tuned in to humans," says Riemer.

"It's humbling to discover that when we tried really hard to raise these dogs in a different, super-positive way, it actually had virtually no impact on the emergence of the cognitive abilities that are important for training," says Hare. "But that's okay – that's good to know." As he and Woods conclude in their book, it neatly demonstrates that all anyone really needs to help a dog feel at home in their home is a caring and sympathetic attitude. ▮

Colin Barras is a freelance science writer based in Ann Arbor, Michigan

CHRIS MALBON

Electric dreams

The hunt for new particles with strange electric charges is hotting up – and if it is succesful, it could have a sesimic effect on physics, says **Jacklin Kwan**

MOST of us don't think much about electric charge, apart from in those annoying moments when our phones run out of it. But for physicists, it is a big deal. In every atom, negatively charged electrons orbit a nucleus containing positively charged protons, with the whole dance sustained by their mutual attraction. It would be fair to say, then, that charge is about as fundamental as it gets.

This explains why physicists have long been at such pains to understand its nature, and for the most part they have been successful. But there is one question that has always hung in the air, unanswered. It seems that the smallest possible unit of charge is that of an electron – all other naturally occurring particles only have multiples of this. In nature, you can find charges of -1 or +3 or -2, but never 0.25. Why is this?

You might shrug and say that is just how the universe is. But in truth, there have always been good reasons to suspect that fractional charges do exist, even if we haven't caught one yet. And it is a particularly live issue today thanks to fresh insights from string theory, one candidate for a theory of everything.

Now, experiments are beginning at the CERN particle physics lab near Geneva, Switzerland, to hunt for particles that could have charges just thousandths that of an electron. If they can find them, it would be an Earth-shattering discovery. "It is no exaggeration to say that observing millicharges would be like the Copernican revolution all over again," says theoretical physicist Jonathan Feng at the University of California, Irvine.

When physicists say that molecules, atoms and particles can only have charges that come in integer values, they mean whole multiples of the elementary charge (1.6×10^{-19} coulombs, for those taking notes). This is the charge attached to two of the basic constituents of atoms: electrons and protons (the former being negative, the latter positive). So naturally, when atoms or molecules gain or lose electrons in chemical reactions, they build up charge in correspondingly discrete quantities.

But these waters run much deeper than that. The standard model of particle physics sets out our best account of the particles that make up reality. Glance at this and you see that, although not all particles have an electric charge, those that do tend to follow the same pattern. For instance, the muon and tau have a -1 charge and the W boson can be +1 or -1.

Yet there are three reasons to think this isn't the end of the story. First, we know for a fact that the standard model doesn't cover everything, not least because it is silent on the topic of dark matter, a substance we are pretty sure exists, but can't identify.

Second, there is a caveat to all the above in that quarks, another fundamental particle of matter, buck the trend. They have a charge of either +2/3 or -1/3, but are never found in isolation, only in pairs or triplets arranged so that their cumulative charge is always a whole number. This shows that fractional charge isn't strictly impossible – which prompts the question of whether there could be other examples out there.

Third, there is the work of theoretical physicist Paul Dirac nearly 100 years ago, which provides a further hint that there is something strange going on with charges. To get your head around it, you need to know that physics paints electric charge and magnetic "charge" as two intimately related phenomena – indeed, electricity and magnetism both arise from the same force, electromagnetism. In nature, electric charges always occur separately, as positive and negative, but magnetic charges – what we call north and south – apparently always appear together.

Or do they? In 1931, Dirac was thinking about a hypothetical object, a so-called magnetic monopole, which is like a north magnetic charge without its south counterpart (or vice versa). He started by assuming these existed in the form of a particle and, using the newly invented framework of quantum mechanics, he explored how such a particle would behave in the presence of an electric field. He found that, for the maths to work properly, electric charge would have to come in certain fixed quantities. In other words, if magnetic monopoles were to exist, they would offer a mathematical rationale for why electric charge must come in certain fixed quantities. Crucially, the strength of the magnetic charge of the monopole matters: the stronger it is, then the smaller the fundamental unit of electrical charge would be.

To be clear, we have never found a monopole, despite decades of searching, ›

FORMOSA COLLABORATION

The FORMOSA experiment during installation at CERN

involving everything from antennas in Antarctica to meteorites. And that leaves us with a puzzle. Either monopoles really don't exist, in which case we are back to square one and we don't know why electric charge should come in fundamental units, or perhaps they do exist, but they are just so rare or so massive that they are only produced in the most energetic particle collisions, making them devilishly hard to detect. In any case, there remains the possibility that particles with extremely tiny charges are out there, waiting to be discovered.

All scrunched up

One idea that has long pointed in this direction is string theory, the hypothetical framework that sees the fundamental ingredients of reality as one-dimensional "strings" that vibrate in 10 or more dimensions. These extra dimensions would be "compactified", or scrunched up very small, and this could happen in many different ways. Back in 1985, theorists Edward Witten and Xiao-Gang Wen repeated Dirac's analysis in the context of string theory. What they found was surprising. Depending on the specific flavour of string theory, the strength of a magnetic monopole could be five times larger than that originally predicted by Dirac when he assumed that electrons were the most elementary electric charge.

Remember the relationship between electric charges and monopoles? The bigger the monopole, the smaller the fundamental charge. On further inspection, Witten and Wen found that charges five times smaller than that of the electron could be stable. They would exist as strings wrapped around a "hole" in all these extra dimensions of space and time. "Magnetic monopoles, if we could find them, would be very informative about fundamental physics, and I think most theoretical physicists who have thought about it seriously believe they do exist," says Witten. He reckons we may not see them today because of the way the universe expanded rapidly after they were created at the beginning of time, drastically diluting the concentration of monopoles in space.

More recently, other string theorists have been exploring the possibility of particles with even smaller charges. These "millicharged" particles would have an electric charge equal to perhaps thousandths or even millionths of an electron's. This idea originates from a new way of thinking about dark matter. Years ago, physicists hypothesised that this mysterious substance might be made of a single type of new particle, often nicknamed a WIMP, for weakly interacting massive particle. But since searches for these have come up empty-handed, many physicists now suspect dark matter might be composed of a whole suite of different particles – a "dark sector" – much as regular matter is.

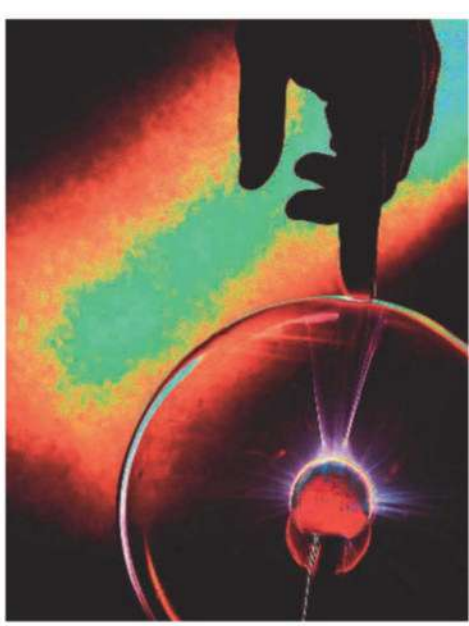
What could these dark sector particles consist of? Well, according to a handful of recent simulations, some of them could be millicharged particles. "The amazing thing is that if you put in particles that are not as heavy as the Higgs boson, but are more like the proton or something lighter, and, at the same time, you make them millicharged, you also get the right amount of dark matter," says Feng.

Experimental hunts for fractionally charged particles date back 30 years, for example at the Stanford Linear Accelerator Center in California. But the new theoretical developments have reignited the chase and a clutch of new detectors are being built and tested, many aiming to snare particles with even the slightest whiff of charge. "Searches have gained a lot of steam recently because there's now this connection to new ideas in string theory: dark sector theories," says Feng.

If millicharged particles do exist, it should be possible to conjure them up using the tried and tested method that yielded the Higgs boson. That involves smashing protons together at incredible speed and hoping that millicharged particles are produced in the debris. This explains why most of the new detectors are being built at CERN, with its Large Hadron Collider (LHC) particle accelerator. These detectors use various arrays of supersensitive scintillators, materials that give off light when hit by charged particles.

The first detector to be constructed at CERN sprang from an experiment called MoEDAL, originally designed to hunt magnetic monopoles. An extension to this experiment capable of spotting millicharged particles, called the MoEDAL Apparatus for Penetrating Particles (MAPP), was installed in 2023 and it began taking data earlier this year. James Pinfold, spokesperson for the experiment, says: "If you sort of buy the argument that there should be monopoles, then, in a sense, you're going to buy the argument for millicharges."

Hot on its heels is another detector called milliQan, which has just finished a set of upgrades in 2024, after it first began taking data in 2018. It is above ground, unlike MAPP, which is shielded from interfering cosmic



CREATIVE COLLECTION TOLBERT PHOTO/ALAMY

rays by being 100 metres underground. Because of this, milliQan relies on artificial shielding made of concrete and lead. The two experiments are tuned to search for millicharged particles in different mass ranges and with different lifetimes, with milliQan able to detect particles with charges as small as a few per cent that of an electron. MilliQan had a few test runs that prove its parts were working, and improved data runs are continuing at the moment.

Then there is the FORMOSA experiment, which has just begun prototyping its CERN detector this year. Physicist Yu-Dai Tsai at the University of California, Irvine, who proposed FORMOSA, says it is also complementary with milliQan and MAPP, searching for particles with different masses and at different electric charge ranges. All use techniques to screen out the noise made by other charged particles that we know of, such as muons.

CERN doesn't have a monopoly on these hunts, though. Other scintillator-based experiments include LANSCE-mQ at the Los Alamos National Laboratory, New Mexico, which is due to begin construction in 2025, and the SUB-Millicharge ExperimenT (SUBMET) at the Japan Proton Accelerator Complex, which has recently begun taking data. Compared with the experiments that Feng witnessed while he did his PhD decades ago, the recent efforts have improved sensitivities by a factor of 10 or more. "These new searches are a very different kind than the ones that have been going on for decades," says Feng.

We haven't found any millicharges or fractionally charged particles yet, but doing so could have ramifications that go way beyond particle physics, and indeed back to a mysterious phase of the early universe. We think that, very shortly after the big bang, the universe blew up in size at an astonishing speed, through a process called inflation. However, this would have left it far emptier than it is now, so theorists reckon some of the energy causing the inflation must have been converted into a flood of particles. This energy-to-particles period is known as "the reheating epoch" and, in line with that name, it would have had a characteristic temperature. According to some dark sector models and string theory, the particles that sprang from this event would have included all the familiar ones from the standard model, plus millicharges and monopoles.

A vital clue

Despite it being a critical period in cosmological history, there is no experimental benchmark for what this reheating temperature ought to be, which is a big problem. The temperature at which the universe reheated determines how hot and dense conditions were right after inflation and how much energy was available to create the particles around us. The reheating temperature, therefore, affects the very abundance of matter and radiation that eventually evolved into galaxies, stars and planets. That, according to Tsai and his colleague Xucheng Gan at New York University, is where these millicharges could give scientists a vital clue – their masses would be dependent on the reheating temperature, so finding them would give us a way of looking back at that temperature.

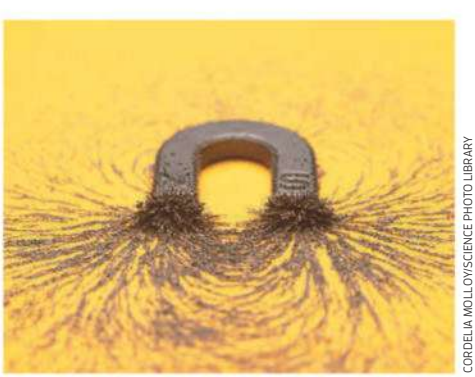
There may – if we are very lucky – be a sneaky shortcut in the hunt for fractionally charged particles. Thanks to the subtle connection between millicharges and monopoles, if we were to find the latter, that might enable us to infer something about the existence of the former. True, we have already been searching unsuccessfully for monopoles for decades – but there is now a surprising new way to seek them.

Nick Mavromatos at King's College London and several colleagues working on the MoEDAL experiment recently came up with this new tactic. Instead of using MoEDAL to hunt for monopoles produced in particle collisions, the team would conjure one of these lonely poles from thin air. The idea quite isn't as wild as it might sound. Quantum physics teaches us that empty space is fizzing with pairs of virtual particles and antiparticles, which fleetingly pop into existence before mutually annihilating. But pump enough energy into a vacuum and these particles can be forced apart and made real through what is known as the Schwinger mechanism.

To produce a monopole in this way, "pumping in enough energy" means applying an extremely strong magnetic field. And the team realised that they already have exactly this at their fingertips: particular collisions at CERN's accelerators involving lead ions produce very large fields. "These are the strongest magnetic fields in the known universe," says Mavromatos. He and the team reasoned they might be powerful enough to coax a virtual monopole from out of the void.

Earlier this year, Mavromatos and his colleagues published a report on just such an experiment. By this point, you will hardly be surprised to hear that they didn't snare a monopole. But the team plans to try again when the LHC gets a planned upgrade, hopefully by 2030, which would make the approach sensitive to even tinier charges. It may seem disappointing, but then again, what is another few years when we have already been hunting these strange charges for a century? ▮

"Millicharges would give us a vital clue to the temperature of the early universe"



The forces we think of as electricity (left) and magnetism (right) are deeply linked at the fundamental level

CORDELIA MOLLOY/SCIENCE PHOTO LIBRARY

Jacklin Kwan is a science journalist based in London

The back pages

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Picturing the lighter side of life p48

Debunking gardening myths

Walking on eggshells

A classic gardening tip is to surround plants with crushed eggshells to put off slugs. Shame it doesn't work, says **James Wong**

James Wong is a botanist and science writer, with a particular interest in food crops, conservation and the environment. Trained at the Royal Botanic Gardens, Kew, in London, he shares his tiny flat with more than 500 houseplants. You can follow him on X and Instagram @botanygeek

FOR as long as I have been gardening, there has been a tip I have come across at least once a week: the idea that a ring of crushed eggshells placed around plants is an effective, natural barrier to slugs and snails. With more and more gardeners keen to avoid the use of pesticides, could this age-old advice be ever more relevant to home growers? Let's take a look at the science.

Here is how it is supposed to work: the sharp, rough edges of the crushed eggshells are thought to be irritating to the soft, smooth bodies of slugs and snails, so sprinkling a ring of these or other rough-textured aggregates like grit, sand or chipped pine bark around plants creates a sort of impassable barrier.

The surprising thing to me is that trials have consistently shown that rough aggregates are ineffective impediments to the movement of land molluscs. A 2018 study found that lettuce plants encircled by a range of these materials didn't fare any better against slugs and snails than control plants with zero barriers. It is thought this is because the thick mucus these creatures produce to slide along creates a smooth, slippery trail across even very sharp surfaces.

In fact, other trials have shown that slugs are attracted by the scent of yeast, so it isn't unreasonable to propose that trace remnants of decomposing raw egg found in these shells could actually act as a lure to the very creature you are trying to avoid.

BIOSPHOTO/ALAMY

However, other natural barriers might be worth considering. Coffee grounds have been shown to be effective at reducing the keeness of slugs to munch on young plants in at least one trial. The problem is the caffeine responsible for their effectiveness is also toxic to plants, meaning the grounds need to hit the sweet spot where their caffeine levels are low enough to be safe to use on plants, but still high enough to work on slugs. Not exactly easy to do at home.

So far, the best evidence seems to be for a solution of garlic extract, which trials have shown promising results for. Its active ingredient, allicin, is, however, the same compound that makes garlic give you terrible breath. And I can personally attest to the looks even your most polite neighbours give you when you have been out spraying garlic on your plants.

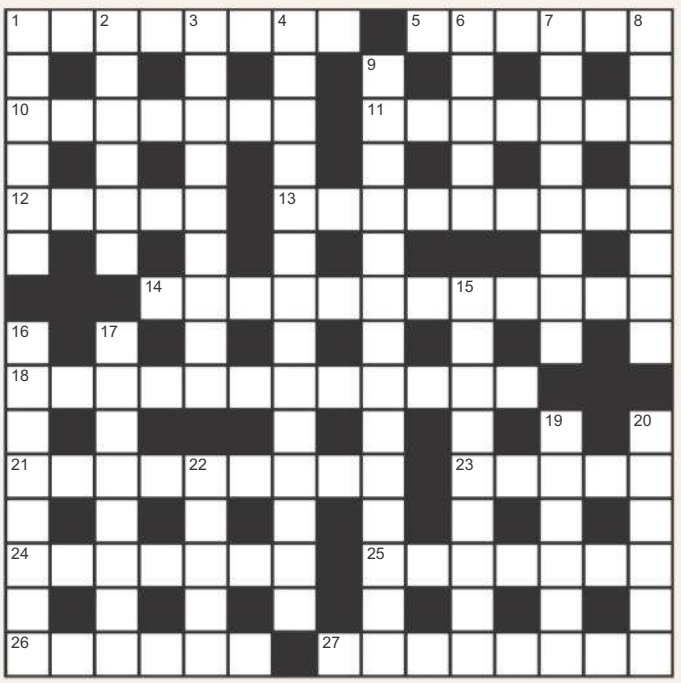
But what if the problem was really of our own creation? In reality, only a few species of slugs and snails actually eat live plants. Many actually help break down dead plant matter, unlocking their nutrients, resulting in healthier soil and better plant growth. They also form an important part of the wider ecosystem as food for the songbirds many gardeners are trying to attract. So, aside from very small seedlings and a few particularly vulnerable plants, such as dahlias, getting rid of slugs and snails may even be doing more harm than good. ▮

Debunking gardening myths appears monthly

Next week
The science of exercise

These articles are posted each week at newscientist.com/maker

Quick crossword #172 *Set by Richard Smyth*



Scribble zone

Answers and the next cryptic crossword next week

ACROSS

1 Liver disorder (8)
5 Mite (6)
10 Genus of moths (7)
11 Requiring oxygen (7)
12 28.35 g (5)
13 Hung (9)
14 Small, flightless marine bird (5,7)
18 Deep-sea submersibles (12)
21 Launch preamble (9)
23 Control system of a machine (5)
24 Prompts, triggers (7)
25 Nb (7)
26 Pigmented area of the breast (6)
27 H (8)

DOWN

1/6 Iréne ___, physicist and chemist (6-5)
2 180 degree changes in direction (1-5)
3 One-humped camel (9)
4 Fear of enclosed spaces (14)
6 See 1 Down
7 Ru (8)
8 Decryption (8)
9 Pseudocyesis (5,9)
15 Danish physicist (5,4)
16 X-coordinate (8)
17 Compound of magnesium ammonium phosphate (8)
19 Dehydrating (6)
20 Enlarge the image seen in a camera lens (4,2)
22 Robot conceived by Stanislaw Lem (5)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #280
set by Bethan Ackerley

1 The abundance of which metal in a layer of Earth's crust provided crucial evidence that an asteroid impact was the cause of the Cretaceous–Palaeogene mass extinction, 66 million years ago?

2 The tricuspid valve is on which side of the human heart, the right or the left?

3 Who proved Fermat's last theorem in the 1990s?

4 Which of the following shark species gives birth to live young: sandbar sharks, hooded carpet sharks or white-spotted bamboo sharks?

5 The splitting of a mature plant to release its contents, such as seeds, is known as what?

Answers on page 47

BrainTwister
set by Christopher Dearlove
#48 Rock, paper, scissors

In the game of rock, paper, scissors, two players simultaneously pick and display one of these options to see who wins. Paper wraps rock, scissors cut paper and rock blunts scissors – each scoring 1 point to the winner and -1 to the loser. If both pick the same option, both score 0.

If both players pick rock, paper or scissors at random, what is the largest the total of their two scores could be after 10 games?

After paper wraps rock, we still have a rock; and although scissors cut paper, paper is cheap. But the rock blunting the scissors is more serious. So, in a variant, we decide to award 2 points in this case and -2 to the loser. Instead of choosing at random, what is the best strategy for each player in this case?

How does this change if we assign 3 and -3 points to the "rock blunts scissors" outcome? Or, in general, N points?

Solution next week

Getting hairy

Why do we start growing copious amounts of ear, nose and eyebrow hair as we get older? How can this possibly help us survive in our twilight years?

David Muir
Edinburgh, UK
It is thought that this excess hairiness is caused by hormonal changes as we age.

A mutation, or random change, in a gene can result in an inheritable characteristic that can be beneficial, harmful or neutral. A beneficial mutation may be successful, or "selected for", and increase in a population. Harmful mutations would be "selected against", a euphemistic way of saying that the carrier could be more likely to die or, at the very least, have little reproductive success. Natural selection doesn't operate on neutral mutations.

But a gene can affect more than one trait! A characteristic can become established in a population because natural selection favours another characteristic with which the first is genetically correlated. Let's pretend that a mutation manifests itself by giving its possessor superior intelligence, but also leads to a hormonal effect in older age causing hairy ears and nostrils. If superior intelligence is positively selected for, then old hairy ears and nostrils would become more common by default, even though they offer no survival benefit and are unlikely to enhance reproductive success.

> **"Clearly, this hair growth confers no survival benefit. On the other hand, there also seems to be no downside"**

Another idea is that old hair doesn't have enough energy to push itself all the way through the scalp, so it finds alternative, lower exits via earholes and nostrils...

Douglas Nichols
Hobart, Tasmania, Australia
For a desirable trait – such as an absence of ear or nose hair later in life – to spread in the population until it becomes the norm, those lucky people who possess that trait must, as a result, generally have more than the average number of children. The genes involved will then become increasingly common as the generations go by.

But there is a problem. How can genes that reduce unwanted hair later in life affect how many children you have earlier in life? If those genes happened to also provide some other advantage – one that manifests itself in youth – then we would be in luck. Failing that, we are saddled with the hair I'm afraid!

Peter Bursztyn
Barrie, Ontario, Canada
Clearly, this hair growth confers no survival benefit. On the other hand, there also seems to be no downside. Either way, this can't have been due to natural selection pressure.

Our bodies appear to have a "design life" of 50 to 60 years, meaning that things begin to go awry after then. For the most part, we stop reproducing around the age of 40. By age 55, our last child will have been reared to "adulthood" (as defined by most societies prior to 1900). Therefore, changes in our bodies after age 40 are unlikely to affect natural selection – although they will be preserved in the genetic record.

SHUTTERSTOCK/JENNIFERNIK

Why do so many Scottish animals, like this Highland cow, have red fur or hair?

I needed corrective lenses for myopia (short-sightedness) by age 10. My myopia requires far more correction in my right eye than my left. As a youth, my father required the same unequal correction, as did my brother, clearly hereditary through the male line.

I often wondered what survival benefit that might have offered. My best explanation is linked to the tendency of *Homo sapiens* to live in cooperative groups. My inability to focus at distance would make me a poor hunter, but would have been a superpower when it came to creating stone tools or sewing skins into clothing and teepee covers. My clan would have fed me in exchange for my valuable skills in other endeavours.

Moreover, since stone knapping and sewing are low-risk occupations, I would have lived longer than most. Longevity would have given me time to develop wisdom – another superpower the clan might have valued.

This week's new questions

Red shift **Why do so many Scottish animals have red fur or hair, such as red squirrels, red deer, Highland cows and red-headed humans?** ***Siobhan McManus****, Glasgow, UK*

Early days **How do human infants think and communicate before they acquire language?** ***Paul Seedhouse****, Newcastle upon Tyne, UK*

More than four

As Earth's rotation slows, how long will it be before the rules for deciding on leap years have to be revised?

Chris Daniel
Glan Conwy, UK
Leap years are needed because it takes Earth about 6 hours, or a quarter of a day, more than 365 days to complete one orbit round the sun. An extra day in the calendar every four years allows Earth time to catch up with where it should be. If this weren't done, the seasons would gradually get earlier in the year.

Over a period of 400 years, a total of 96.88 days need to be added to the calendar. The nearest whole number to this is 97. To achieve this, a leap year is omitted if the year is divisible by 100 but not by 400 – hence the years

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Tom Gauld
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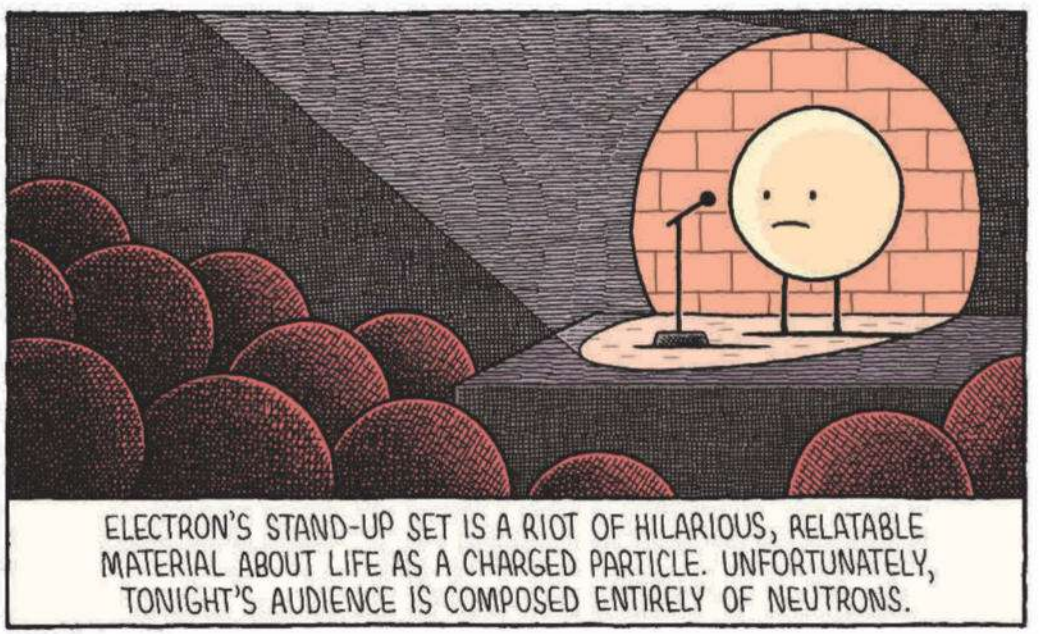

ELECTRON'S STAND-UP SET IS A RIOT OF HILARIOUS, RELATABLE MATERIAL ABOUT LIFE AS A CHARGED PARTICLE. UNFORTUNATELY, TONIGHT'S AUDIENCE IS COMPOSED ENTIRELY OF NEUTRONS.

1800 and 1900 weren't leap years, but 2000 was.

However, even this pattern won't be accurate enough over a longer period, and in the year 3600, the extra day may have to be omitted again to keep the planet and the calendar aligned.

Earth's daily rotation on its axis is slowing at a rate of nearly two-thousandths of a second every century. This means that while Earth's orbit around the sun will still take the same length of time, each day will gradually become longer than 24 hours.

At the end of each year of these longer days, there will be a decreasing fraction of a day remaining for Earth to complete its orbit round the sun, so it will take more time to accumulate the need for a leap year. The first leap year to disappear completely would be the regular one at the end of a century divisible by four, as only 96 leap years would be required every 400 years instead of 97. This would happen in 29,000 years, when Earth's day will be half a second longer than it is now.

"Our calendar years are too long by 0.0003109 days, so, after 3216 years, five months and a few days, we will be one day ahead"

Hillary Shaw
Newport, Shropshire, UK

Earth's days are getting longer by 1.8 milliseconds per century. But a leap year change will first be necessary because of another issue: the Gregorian calendar year is 365.2425 days, while an actual year is 365.2421891 days long.

This slight mismatch means our calendar years are too long by 0.0003109 days, so, after 3216 years, five months and a few days, we will be one day ahead – what we would call 2 January in the year 5240 should in fact be 1 January. We could then institute an amendment to the Gregorian calendar, namely: "If the year is divisible by 3200, have an extra leap day." So, in such years, we would have a 30 February. Call this the Anthropocene calendar.

Lengthening days should, in theory, save us from the aberration of 30 February – except this effect is rather too small. By the year 9600, our day will be just 0.11 seconds longer. From our current 86,400 seconds in a day, a lengthening of the day by 1.8 milliseconds extra per century means we will only lose one day of our annual calendar in 51.84 million years. So this 3200-year extra leap day rule would need to remain in force until our days had lengthened by 1/3200th of a day, which will take 16,200 years.

The good news is we will only ever need five "February 30ths" before we can revert from the Anthropocene calendar to the Gregorian one in 19,200. By 12,900,000, we will have lost a whole quarter day in the year, now just 365 days long, and can have a very simple calendar where every February has just 28 days in it. In 70 million years, there will be just 364 days in the year (and every February will have just 27 days).

Answers

Quick quiz #280 *Answers*

1 Iridium
2 The right
3 Andrew Wiles
4 Sandbar sharks
5 Dehiscence

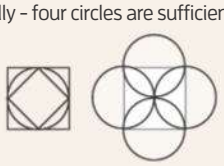
Cryptic crossword #149 *Answers*

ACROSS 1 Cone, **3** Of course, **9** Enteral, **10** Aisle, **11** Talus, **12** Edison, **14** Nudist, **16** Impact, **19** Two-ply, **21** Nyala, **24** Torsi, **25** Polecat, **26** Pap smear, **27** Zinc

DOWN 1 Creatine, **2** Natal, **4** Fuller, **5** Okapi, **6** Roseola, **7** Even, **8** Prises, **13** Atlantic, **15** Dewdrop, **17** Mantle, **18** Myopia, **20** Prism, **22** ASCII, **23** Stop

#47 Squares and circles *Solution*

Rotating the inner square by 45 degrees reveals that it touches the larger square at the midpoints of each edge; it can be seen that the area is half the area of the larger square. A copy of the circle centred at the midpoint of each edge of the square will cover it totally – four circles are sufficient.



The circle inside the square takes up $\pi/4$ of the area, while the square inside the circle takes up $2/\pi$ of the area, which is smaller, and so the circle in a square is a better fit. (Mathematician David Singmaster studied this problem and discovered that this continues to hold for spheres in cubes and for higher dimensions up to 8, beyond which it swaps around.)

COP a load of this

Feedback has been watching bemusedly from a distance as the latest round of international climate negotiations, COP29, struggled along in Azerbaijan. In a previous life, we covered a few COPs, and are still on most of the relevant mailing lists. Hence we know that on 18 November, when we were writing this, Climate Action Network's Fossil of the Day was South Korea, because it was single-handedly blocking a deal that would end subsidies of oil and gas by high-income countries. Yep, that would do it.

Having a conference dedicated to cutting greenhouse gas emissions in a country like Azerbaijan, which is heavily reliant on fossil fuel exports, was always likely to backfire. Feedback thought diplomacy was about understanding others' motivations, but apparently nobody twigged what the Azerbaijan government might want. On cue, President Ilham Aliyev described oil and gas as a "gift from God" in his opening speech, and the country's chief negotiator was filmed apparently arranging a meeting to discuss fossil fuel deals.

Then the conference actually started – or rather it didn't. On day one, the works became gummed up within the first hour, after several countries objected to the agenda for the rest of the conference. The first day was then spent renegotiating the agenda, while the delegates sat around with nothing to do. Still, it's not like climate change is an urgent problem.

Feedback would like to think things can only go uphill from here, but the experience of the past decade suggests otherwise. Besides, we still twitch when we remember the last night of one COP we attended. It was well into the evening, so the agreement should have been signed and the party started. But then we saw a parade of junior diplomats carrying towering stacks of takeaway pizza boxes into the negotiating room – and we realised we were going to be there, even in a best-case scenario, until the early hours of the morning. Feedback doesn't recommend this experience, or the accompanying case of caffeine poisoning.

Twisteddoodles *for New Scientist*

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Find your inner badass

Assistant news editor Alexandra Thompson draws our attention to a paper on the psychological research repository PsyArXiv, with the glorious title "What it means to be a true badass: An experimental investigation of the ordinary concept". Its authors, Breanna Nguyễn and Michael Prinzing, set out to explicate what we mean when we say that someone is a badass. It isn't obvious, they say, because both Genghis Khan and Malala Yousafzai could be described as badasses, but "these two people are about as different from each other as one could imagine". Well, quite.

The researchers used a series of online surveys to clarify what sorts of people did and didn't count as badasses. This revealed, they say, that "badass" is a concept with two layers. There is a superficial meaning, which relates to being physically strong or having a "formidable presence". But there is also a deeper, inner meaning relating to "moral resilience and courage".

According to the authors, Yousafzai exemplifies this inner badassness, while Khan is more about external badassery. Feedback isn't so sure: we have read John Man's biography of Khan and he displayed remarkable courage in tight spots. Still, the inner/outer badass distinction sounds plausible.

In our quieter moments, Feedback sometimes enjoys research like this that digs into the subtle meanings of everyday terms. The classic example is Harry Frankfurt's book *On Bullshit*. Frankfurt was a philosopher who drew a distinction between lying – telling untruths for the purpose of explicitly misleading someone – and bullshitting, or telling untruths without regard for truth or falsehood in order to serve one's own purpose.

On Bullshit is a useful thing to read because it takes something we all implicitly understand and makes it explicit. With the concept clarified, it becomes easier to spot examples, hence the June paper bluntly titled "ChatGPT is bullshit". Also, it is nice to have a word that is both a precise piece of terminology and an enabler of prolific swearing. Frankfurt, we think, was a badass.

Emus in flight

On 15 November, CBS News reported that two "feral and not trained" emus (is there any other kind?) were on the run in South Carolina. They had apparently escaped three months earlier, but their flight hadn't garnered any attention – until 43 monkeys escaped from a medical research facility in the same state. As of 18 November, six of the monkeys remained at large. Faced with a horde of marauding monkeys on the run, journalists started looking for similar stories and found (or rather, didn't find) the rogue emus.

Feedback would never stoop so low as a local police department, which posted that they were "NOT EMU-SED". But we do want to echo the point made by Matthew Downhour on Bluesky: "Okay if they didn't want them to run wild and be irresponsible why did they name them that"? It is a good question, because, you see, the emus are called Thelma and Louise.

If the US authorities are unable to recapture the birds, they could take notes from the Australians, who famously fought a short war against wild emus in 1932. True, the emus won the conflict decisively, but failure is the best teacher.

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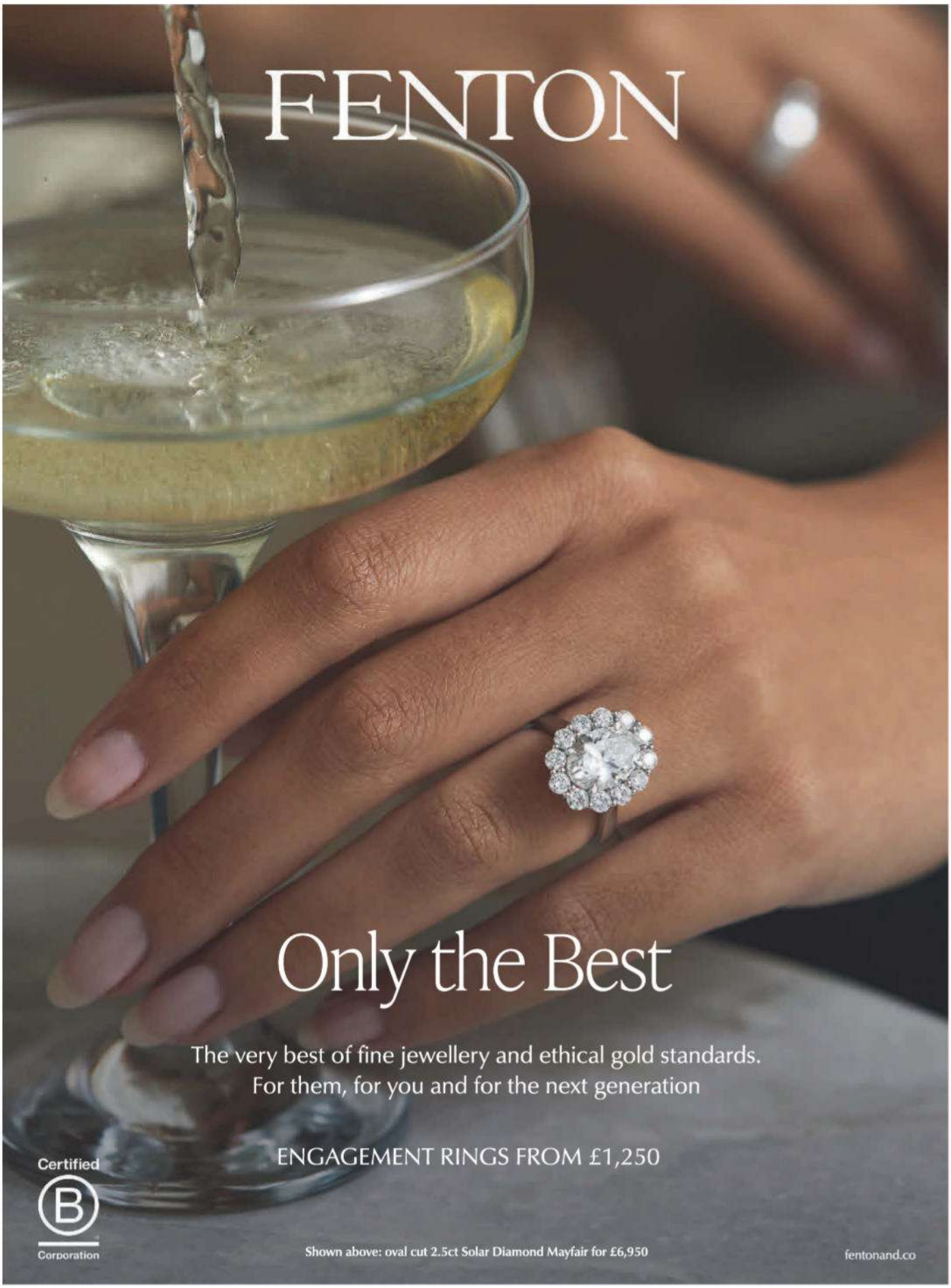
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